

INSTRUMENTATION APPENDIX TO
PERIODIC INSPECTION REPORT NO. 5
UNION VILLAGE DAM, VERMONT

by

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Cambridge, Massachusetts

for

Department of the Army
New England Division

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Letter of Transmittal

Geotechnical Engineers &
Environmental Consultants

To	Department of the Army, N.E. Division, Corps of Engineers	Date	11 August 1995
	424 Trapelo Road	File Number	11163-006
	Waltham, Massachusetts 02254-9149	Subject	Delivery Order No. 4
Attention	Ms. Laura Fraser		DACW33-93-D-0005

Copies	Date	Description
1 ea.	08/11/95	Final Instrumentation Appendix Report for Knightville Dam and Union Village Dam
1 ea.	08/11/95	Reproducible Final Instrumentation Appendix Report for Knightville Dam and Union Village Dam

Remarks

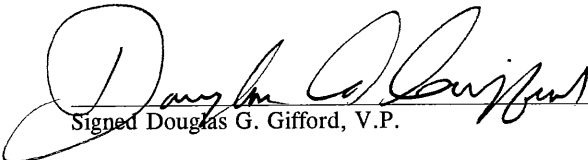
We have enclosed a final bound copy and a reproducible copy of each report. Electronic copies of the reports will be provided under separate cover. Please let us know if you have any additional comments or questions. You may contact either Liz Brown at 494-4910 x201 or A. J. McGinn (x208) or Doug Gifford (x321).

Also included are the previous reports for each dam that were provided to us.

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Signed Douglas G. Gifford, V.P.

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1. Project Performance

Based on visual observation and instrumentation data compiled to date, the dam performance is rated as good. The computed crest monument data shows little settlement (0.4 - 0.8 in.) from 1973 to 1994. Horizontal movement of the crest of the dam was less than 0.6 in. from 1985 to 1994.

Based on the data collected to date, the piezometers appear to be functioning correctly except for PZ-5A and 5B. Piezometers 5A and 5B maintain comparable readings suggesting that the piezometers may be hydraulically connected. However, they respond to fluctuations in pool level and seem representative of the ground water in their area. The instrumentation evaluation is based on the piezometric readings from October 1, 1992 through October 31, 1994.

Since their installation in 1978, the strong motion accelerographs at Union Village Dam have experienced five significant earthquakes and were activated once in 1982 by the Gaza, NH earthquake. The records from this event showed a maximum acceleration of 0.05g (accelerograph at downstream toe of dam). The present schedule for reading all strong motion accelerographs at Union Village Dam is once per month and should be maintained.

2. General Project Description

a. History. Union Village Dam is one of a system of 16 dams and reservoirs constructed by the Corps of Engineers in the Connecticut River Basin for flood control purposes. Union Village Dam and Reservoir have been constructed on the Ompompanoosuc River to protect the downstream community of Union Village. The dam functions with a series of 15 other reservoirs within the basin, to reduce downstream flood stages along the Connecticut River. The project location is shown on Figure 1.

The Union Village Reservoir provides 38,000 acre-feet of storage below the spillway crest at El. 564.0. A general plan view of the dam is shown in Figure 2. This quantity of storage is equivalent to 5.65 inches of runoff from the tributary drainage area of 126 square miles.

The elevations provided are referenced to NGVD datum.

b. Geology and Foundations. The Ompompanoosuc River watershed is situated in an upland area, characterized by narrow steep-side rock valleys separated by high rounded ridges. This topography results from pre-glacial stream surface erosion modified by glacial action. During glacial time the valley was partly filled by extensive accumulations of glacial sediments. In recent geologic time, the sediments were partially carried away by the river. In accomplishing this work the river has cut through the overburden at numerous places and has exposed bedrock. These geologic conditions are shown in the as-built cross sections and profiles included on Figures 3 and 4. Also during subsequent piezometer instrumentation installations, test boring logs were prepared which confirm the typical geologic profile, refer to Figures 5, 6 and 7 for additional data.

(1) Site Geology.

(a) West Abutment and Spillway. The overburden in the west abutment is composed largely of sand containing variable amounts of gravel and glacial silt or rock flour. Both the fine and coarse textured particles of these deposits are angular in shape. Boulders up to three feet in diameter are frequently encountered with those one foot or less in diameter being encountered most frequently. The glacial overburden is composed dominantly of two types of glacial sediment, (1) fine sand and rock flour, and (2) mixtures of sand, gravel and rock flour, together with cobbles and boulders. The fine textured sediments occur in beds of varying thickness. They are prominently developed in the terrace above the river where they form a relatively impervious overburden. The mixed materials comprise most of the valley overburden. These include moderately well-sorted glacial stream or outwash deposits, together with poorly assorted outwash containing much rock flour. The bedrock surface along the centerline of the dam dips beneath the stream to a depth not exceeding 20 ft below river level. It then rises gradually beneath the west abutment. A tributary rock valley underlies much of the spillway area. The north side of this depression forms, in part, the right bank of the spillway channel. The spillway weir structure is located on higher rock on the south side of the depression.

The bedrock is a dark finely laminated schist (phyllite). It is part of a prominent metamorphic formation in Vermont. The constituents are mostly silicate minerals recrystallized from original fine sand and silt sediments. A small amount of carbonate material (calcite) also occurs. The strata have been strongly deformed resulting in pronounced slaty cleavage, which allows the rock to be easily split.

(b) East Abutment and Outlet Works. The east abutment, outlet tunnel and appurtenant structures are constructed on and in rock, which extends from stream level to a height well above the top of the dam. Outcrops are prominent throughout a large part of this area, except in the immediate vicinity

of the downstream portal area. The portal itself is constructed within rock. The tunnel and shaft were excavated in the steeply inclined beds of schist described above.

Seepage through the overburden in the west abutment and through bedrock in the east abutment was controlled by construction of an impervious cutoff in the more pervious portion of the overburden, and by grouting of bedrock in the vicinity of the spillway weir and in the foundation of the dam. The weathered surface of bedrock was stripped over the area of the central impervious core and cracks in the rock were grouted so that a suitable junction of core to stripped bedrock was affected. Replacement of pervious overburden in the west abutment with compacted impervious material reduced the seepage through this abutment.

c. Dam and Appurtenant Structures Description. The dam consists of a compacted earth embankment with rock slope protection; it is approximately 1,100 ft long with a maximum height of 170 ft above riverbed. The crest of the embankment is 30 ft wide at El. 584.0 ft, which is 20 ft above the spillway crest and 5.0 ft above the design surcharge. The embankment slopes vary from 1V on 2.5H to 1V on 3H.

A chute spillway constructed in bedrock is located on the right abutment of the dam with the approach channel floor at about El. 520. The ogee-shaped spillway crest is 388 ft long at El. 564. The discharge channel varies from 100 ft wide to 400 ft wide and its bottom slopes vary from 1 to 7 percent. The flows are returned through a 1,100 ft long channel to Avery Brook, thence another 1,100 ft to the Ompompanoosuc River.

The outlet works consist of an approach channel, intake structure, discharge conduit and discharge channel. The intake channel is about 394 ft long, 23 ft wide with an invert at El. 420. The concrete intake

structure houses the necessary equipment to operate the two 7.5 x 12.0 broom gates with electrically operated gear and drum type cable hoists. These gates regulate the discharge through the 13 ft diameter horseshoe conduit. The total length of the discharge conduit measures 1,236 ft with entrance invert at El. 420 and exit invert at El. 418. The rock cut and earth discharge channel is 60 ft wide and approximately 640 ft long.

The normal pool level for Union village Dam is seasonal. During winter months, October through April, the normal winter pool level fluctuates near El. 437 depending on the amount of precipitation. During summer months, May through September when precipitation is less, the normal summer pool level varies near El. 424.

3. Instrumentation.

a. General. Instrumentation to monitor embankment performance at Union Village Dam consists of three strong motion accelerographs, six crest survey monuments, three piezometer/settlement gages and seven piezometers (three double and one single). The location plan of the instrumentation is shown on Figure 5.

b. Crest Monuments. There are six crest monuments, monument 1 through monument 6, on the dam. The monuments are composed of a 4 inch sonatube filled with concrete and reinforcing rods with a brass disk set into the top. They are located along the downstream crest of the dam (Figure 9). There are five control points that have been installed for monitoring movements of the dam: Monuments A, B, C, D-1 and E. All control points were installed similar to the crest monuments and are assumed to be fixed reference points. The monuments were installed at the dam prior to July 1973.

Six surveys have been performed: July 1973, July 1975, April 1978, April 1985, October 1989 and May 1994. During the 1973 and 1975 surveys, triangulation and levels were performed with manual survey instruments. The horizontal data from the 1973 and 1975 survey were based on triangulation and the 1978 survey was based only on distances. The 1978, 1985, 1989 and 1994 surveys were performed with an electronic distance meter (EDM). The 1985, 1989 and 1994 surveys were based on angles and distances and were tied to the state coordinate system. This report uses the vertical data from all surveys and horizontal data only from the 1985, 1989 and 1994 surveys. The results of the surveys are presented on Figures 9 and 10. For reference, the current standards and procedures employed by the Corps of Engineers surveyors for crest monument surveys at Union Village Dam are contained in Appendix A.

c. Piezometers. Fifteen open type piezometers were installed during construction, located on the crest, upstream and downstream slopes, and right abutment. Since then all but three (A-3, A-4, and B-3) have been abandoned. In 1992, seven Casagrande open-type piezometers (three double and one single) were installed at the locations shown on Figure 5. The test boring and piezometer logs for the piezometers installed in 1992 are presented on Figure 7.

The piezometers installed during construction were a combination piezometer and settlement gage which included a 24" x 24" x 1/4" steel settlement plate located between the dam embankment and the prepared foundation. The actual piezometer tip elevations are not known, but soundings were performed in 1988, and those results are shown on Table I.

d. Strong Motion Accelerographs. In 1978, three strong motion accelerographs were installed at Union Village Dam to monitor shock wave attenuation through the embankment and foundation during an earthquake. One, shelter "B", is located on the crest of the embankment just outside the downstream quadrille of the dam. The second, shelter "A", is located on the east abutment on bedrock, approximately 400 ft downstream of the operating house. The third, shelter "C", is located on the in-situ soil to the right of the outlet channel, approximately 1,000 ft downstream of the centerline of the dam. The SMA-1 accelerographs are compact, portable, self-contained units with three accelerometers for measuring and recording motions in three orthogonal directions. The units are activated automatically by an omnidirectional trigger sensitive to vertical accelerations. These accelerations are designed to be activated by a vertical acceleration of 0.01g.

4. Data Collection, Interpretation and Evaluation.

a. Crest Monuments.

(1) Data Collection. Survey data, including coordinates and elevations of the crest monuments for the six surveys completed between 1973 and 1994 are tabulated on Figure 9. Due to the methodology differences, horizontal survey data from the crest monument surveys performed in 1973, 1975, and 1978 could not be used and the survey data are not shown. For reference, distances between control points and crest monuments for the survey performed in 1994 are shown on the plan along with the locations and elevations of control points which are assumed to be fixed reference points (Figure 9).

(2) Interpretation and Evaluation. The 1973 and 1975 surveys were performed using transits to a third order accuracy (1:5000). The 1978, 1985, 1989 and 1994 surveys were performed using EDM's and third order accuracy according to the standards and procedures contained in Appendix A. However, only the 1985, 1989 and 1994 surveys were tied to the state coordinate system. The elevation surveys indicate that the total settlement of all monuments was limited to less than 0.07 ft (0.8 in.) over this twenty-one year period. A crest settlement profile is shown on Figure 10. The pattern of settlement shown reflects the thickness of the embankment fill. The monuments located above the areas with the largest amount of fill, monuments 2, 3, 4 and 5, show the most settlement. Monuments on or near the abutments, monuments 1 and 6, show less settlement. The limits of the old river channel range approximately from Sta. 17+10 to Sta. 18+50, corresponding to monuments 4 and 5. The depths of fill in this area range from approximately 100 ft to 160 ft with a measured cumulative settlement of 0.8 to 0.9 in. Monument 1, located near the West abutment where there is little to no fill, shows a cumulative settlement of 0.4 in. The differential settlement between the center of the embankment and the West abutment is approximately

0.4 to 0.5 in. A representative plot of settlement versus time shows linear time-settlement behavior for the data from 1973 to 1994, as shown in Figure 11.

The results from the 1985 and 1994 survey indicate horizontal movements less than 0.05 ft (0.6 in.), with a typical pattern of downstream movement as shown in Figure 10. However, this range of movement is within the range of third order accuracy.

The data which has been acquired to date indicates that there has been little vertical and horizontal movement within the embankment. However, a settlement pattern reflecting the amount of fill placed along the embankment centerline has developed and the rate of settlement appears to be linear with time.

b. Piezometers.

(1) Data Collection.

Reading Schedule. Piezometer monitoring at Union Village Dam is performed manually.

The minimum piezometer reading schedule presently in effect is as follows:

- Routine. During periods when the reservoir level is below El. 450, a reading of all piezometers and the pool elevation should be made at least once a month. When access to piezometers is made hazardous by snow or ice, the readings may be deferred until safe passage is possible.

- High Pool. During periods when the reservoir level is above El. 450, readings of all piezometers and pool elevation should be made on a daily basis. On a falling pool, the piezometers should continue to be read daily for five days after the pool has returned to its normal elevation.



- Special Conditions. If unusual changes in readings develop or if piezometers become inoperable, the Geotechnical Engineering Division should be notified.

Readings obtained from the piezometers are presented in Table II. Pertinent information includes the date of reading, pool stage and elevation, and piezometer water elevations.

(2) Interpretation and Evaluation.

(a) Presentation of Data. Numerous plots have been developed to present the piezometric data. All the plots were developed using "Quattro Pro for Windows" Version 6.0 computer software. The piezometer plots fall into three categories: time-history, event and "x-y" plots.

Time-history plots were developed for years 1992-1994 and are presented on Figures 12 through 14. Event plots were produced for the rising pool of April 1993 and are shown on Figures 15 through 17. An x-y plot of piezometer water level elevation vs. pool elevation was developed for each piezometer and is shown on Figures 18 through 26. These plots incorporate piezometric data from October 1, 1992 through October 31, 1994 and include a projection of the piezometer level corresponding to a pool elevation at the spillway crest. This projection was calculated by linearly regressing the piezometer data provided and plotting the best fit line.

During both summer and winter months, the "average" water level in each piezometer was calculated using water levels obtained when the pool was close to the seasonal normal pool level. For example, for a normal winter pool of El. 437, piezometric water levels corresponding to a pool level range of El. 435 to El. 438 were used to calculate the "average" winter water level for each piezometer. However, because of staff shortages and reduced access to the piezometers, a limited amount of data was

available to compute average values. Therefore, all piezometric data, including static, rising and falling readings obtained when the pool was between El. 435 and El. 438 were used to calculate the "average" winter piezometric water level. The same procedure was used to calculate the "average" summer water levels for a normal summer pool of El. 424, when the pool level ranged from El. 424 to El. 426.

It should be noted that these "average" piezometric water levels were calculated based on a very limited set of data and were used to create a basis for a comparison to the high pool data of April 1993.

(b) Individual Piezometer Response. All pertinent information (station, offset, tip elevations, zone and material type at tip location) for each piezometer is listed on Table I.

(1) PZ-B-3. PZ-B-3 was installed during the construction of the dam and is approximately located at Sta. 17+40, offset 10 ft downstream from the dam centerline. The top of the riser pipe is at El. 585. The piezometer tip was scheduled at El. 403 in olive brown silty SAND (SM) at the bedrock-foundation soil interface. However, a sounding performed in 1988 showed the tip to be at El. 414.5, within the impervious core. The piezometer originally served as a settlement gage as shown in Figure 28.

During the winter months, the average water level in PZ-B-3 is approximately El. 440, up to 5 ft higher than the normal pool level ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 424 for pool levels ranging from El. 424 to 426. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 14. A noticeable response to the flood events of April 93 and April 94 can be seen in Figures 14 and 17. The water level in the standpipe rose 40 percent of the pool level increase in April 93. Consequently, PZ-B-3 may still be linked to the underlying bedrock, and/or bedrock

may have been locally higher at this location. The measured water levels in PZ-B-3 appear to respond in a linear manner to changes in pool elevation as shown in Figure 18. Based on a linear projection, the water level in the piezometer should rise to El. 480 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figure 17. Based on the flood event shown, the following performance was noted. PZ-B-3 shows a response time of 2 to 3 days to a rising pool. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in the piezometer rose nearly 18 ft from its average winter level to a maximum level of El. 457.8 on 23 April.

(2) PZ-A-3. PZ-A-3 was installed during the construction of the dam and is approximately located at Sta. 17+40, offset 150 ft downstream from the dam centerline. The top of the riser pipe is at El. 536.7. The piezometer tip was scheduled at El. 414.3 in the random fill consisting of (SP-SM, SP and SM). A sounding performed in 1988 showed the tip to be at El. 416, probably still within the random fill. The piezometer originally served as a settlement gage as shown in Figure 28.

During the winter months, the average water level in PZ-A-3 is approximately El. 424 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 420 for pool levels ranging from El. 424 to 426. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 14. The measured water levels in PZ-A-3 appear to respond linearly but in small proportion to changes in pool elevation as shown in Figure 19. The smaller range of piezometric levels for PZ-A-3 is to be expected due to its location beneath the downstream slope at the toe drain-foundation soil interface; the drain outlets to tailwater which varies from about El. 419 to 421. Based on a linear projection, the water level in the piezometer should rise to only El. 425 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figure 17. Based on the flood event shown, the following performance was noted. PZ-A-3 shows a response time of 5 to 6 days to a rising pool. The longer response time is representative of the piezometers location. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in the piezometer rose about 3 ft from its average winter level to a maximum level of El. 426.6 on 25 April. The maximum level is approximately 2 ft above the projected piezometric level for a pool level equal to the spillway crest, El. 564. The lower value of the projected level is attributed to the accuracy of the projection based on the limited data points and the small range of piezometric data available for PZ-A-3.

(3) PZ-A-4. PZ-A-4 was installed during the construction of the dam and is approximately located at Sta. 17+40, offset 300 ft downstream from the dam centerline. The top of the riser pipe is at El. 486.7. The piezometer tip was scheduled at El. 415.9 in the pervious sand (SP-SM, SP). A sounding performed in 1988 showed the tip to be at El. 417.7, probably still within the pervious sand. The piezometer originally served as a settlement gage, as shown in Figure 28.

During the winter months, the average water level in PZ-A-4 is approximately El. 421 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 418 for pool levels ranging from El. 424 to 426. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 14. The measured water levels in PZ-A-4 appear to respond in a linearly but in small proportion to changes in pool elevation as shown in Figure 20. The smaller range of piezometric levels for PZ-A-4 is to be expected due to its location beneath the downstream slope at the toe drain-foundation soil interface; the drain outlets to tailwater which varies from El. 419 to 421. Based on a linear projection, the water level in the piezometer should rise to El. 424 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figure 17. Based on the flood event shown, the following performance was noted. PZ-A-4 shows a response time of 5 to 6 days to a rising pool. The longer response time is representative of the piezometer's location. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in the piezometer rose nearly 2 ft from its average winter level to a maximum level of El. 422.9 on 25 April.

(4) PZ-5A. PZ-5A was installed in 1992 and is approximately located at Sta. 17+40, offset 105 ft upstream from the dam centerline. The top of the riser pipe is at El. 552. The piezometer tip is located at El. 398 in bedrock, consisting of black schist with vertical fractures. The piezometer is made of a wick of filter sand that extends 8.8 ft upward from El. 393.2 to a bentonite seal.

During the winter months, the average water level in PZ-5A is approximately El. 444 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 431 for pool levels ranging from El. 424 to 426. Both the summer and winter piezometer values are higher than the average pool values for their respective season. This may be due to the location of PZ-5A in bedrock where artesian pressures could develop relative to pool level. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 12. The measured water levels in PZ-5A appear to respond in a linear manner to changes in pool elevation as shown in Figure 21. Based on a linear projection, the water level in the piezometer should rise to El. 544 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figure 15. Based on the flood event shown, the following performance was noted. PZ-5A shows a response time of 1 day to a rising pool. The maximum pool level

of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in the piezometer rose nearly 51 ft from its average winter level to a maximum level of El. 495.0 on 14 April.

PZ-5A and 5B respond in the similar fashion to fluctuations in pool level. Their piezometric levels vary by no more than 0.1 ft. Similar readings may be attributed to an ineffective seal between the two piezometers. Thus, the piezometers no longer monitor separate zones, instead, they are influenced by the same zone. The lower piezometer, PZ-5A, monitors the piezometric level in the bedrock and the upper piezometer, PZ-5B monitors the piezometric level in the overburden foundation. The rapid response of both piezometers to fluctuation in pool level may be related to the location of PZ-5A in the bedrock and the influence of the steeply sloping rock beneath the east abutment.

(5) PZ-5B. PZ-5B was installed in 1992 and is approximately located at Sta. 17+40, offset 105 ft upstream from the dam centerline. The top of the riser pipe is at El. 552. The piezometer tip is located just below the foundation/embankment interface at El. 410 in olive brown silty (15-25) SAND (SM). The piezometer consists of a wick of filter sand that extends 14 ft upward from El. 406 to a bentonite seal as shown in Figure 8.

During the winter months, the average water level in PZ-5B is approximately El. 444 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 431 for pool levels ranging from El. 424 to 426. Both the summer and winter piezometer values are higher than the average pool values for their respective season. This may be due to the hydraulic connection to PZ-5A in its location in bedrock. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 13. The measured water levels in PZ-5B appear to respond in a linear manner to changes in pool elevation as

approximately El. 419 for pool levels ranging from El. 424 to 426. The piezometric level, El. 458.4, taken on 31 October 1994 was not used in the average summer calculation due to its higher value compared to the other piezometer data for the same day. The abnormally high reading may be due to moisture in the stand pipe that prematurely set off the water level sensor. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 12. The measured water levels in PZ-6A appear to respond slightly to changes in pool elevation as shown in Figure 23. Based on a linear projection, the water level in the piezometer should rise to El. 429 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figure 15. Based on the flood event shown, the following performance was noted. PZ-6A shows a response time of 4 to 5 days. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in the piezometer rose nearly 11 ft from its average winter level to a maximum level of El. 432.9 on 23 April. The maximum level is approximately 4 ft above the projected piezometric level for a pool level equal to the spillway crest, El. 564. The lower value of the projected level is attributed to the accuracy of the projection based on the limited data points and the small range of piezometric data available for PZ-6A.

(7) PZ-6B. PZ-6B was installed in 1992 and is approximately located at Sta. 17+40, offset 30 ft downstream from the dam centerline. The top of the riser pipe is at El. 579. The piezometer tip is located in the select impervious embankment zone at El. 418.8 in olive brown silt (ML). The piezometer consists of a wick of filter sand that extends 72.8 ft upward from El. 417.3 to a bentonite seal as shown in Figure 8.

During the winter months, the average water level in PZ-6B is approximately El. 426 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 421 for pool levels ranging from El. 424 to 426. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 13. The measured water levels in PZ-6B appear to respond somewhat to changes in pool elevation as shown in Figure 24. Based on a linear projection, the water level in the piezometer should rise to El. 438 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figure 16. Based on the flood event shown, the following performance was noted. PZ-6B shows a response time of 3 to 4 days for a rising pool, about one day faster than the response of PZ-6A. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. The water level in the piezometer rose 6.8 ft from its average winter level to a maximum level of El. 432.9 on 17 April, six days prior to the maximum level of PZ-6A. The readings for PZ-6B are consistently higher during flood events than PZ-6A. This matches seepage behavior that is consistent with flow net models for flow through a dam. A faster response time of one day for piezometer 6B compared to 6A may be insignificant due to the slow response time for both piezometers.

(8) PZ-7A. PZ-7A was installed in 1992 and is approximately located at Sta. 17+40, offset 225 ft downstream from the dam centerline. The top of the riser pipe is at El. 513. The piezometer tip is located just above the bedrock/foundation interface at El. 399.2 in very dark grayish brown silty (18.4) SAND with gravel (27.4) (SM). The piezometer consists of a wick of filter sand that extends 21.2 ft upward from El. 392.8 to a bentonite seal as shown in Figure 8.

During the winter months, the average water level in PZ-7A is approximately El. 422 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 419 for pool levels ranging from El. 424 to 426. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 12. The measured water levels in PZ-7A appear to respond somewhat to changes in pool elevation as shown in Figure 25. The small range of piezometric levels for PZ-7A is to be expected due to its location beneath the downstream slope with resulting connection through jointed bedrock or fill/rock interface to tailwater outlet. Based on a linear projection, the water level in the piezometer should rise to El. 427 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event-plot, Figure 15. Based on the flood event shown, the following performance was noted. PZ-7A shows a response time of 4 to 5 days to a rising pool. The longer response time is a result of the piezometers location on the downstream slope. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in the piezometer rose nearly 3 ft from its average winter level to a maximum level of El. 425 on 23 April.

(9) PZ-7B. PZ-7B was installed in 1992 and is located at Sta. 17+40, offset 225 ft downstream from the dam centerline. The top of the riser pipe is at El. 513. The piezometer tip is located at El. 420 in the downstream random fill zone in olive brown poorly graded SAND with silt (11.1) and gravel (27.4) (SP-SM). The piezometer consists of a wick of filter sand that extends 4.9 ft upward from El. 418.1 to a bentonite seal as shown in Figure 8. PZ-7B provided no readings during the period October 1, 1992 through October 31, 1994. The piezometer tip was apparently installed above the normal tailwater level which controls the water level in the lower random fill zone.

(10) PZ-8. PZ-8 was installed in 1992 and is approximately located at Sta. 17+40, offset 450 ft downstream from the dam centerline. The top of the riser pipe is at El. 440. The piezometer tip is located just above bedrock in the stratified foundation at El. 386.9 in olive brown silty (15-25) SAND with gravel (25-35) (SM). The piezometer consists of a wick of filter sand that extends 31 ft upward from El. 380 to a bentonite seal as shown in Figure 8.

During the winter months, the average water level in PZ-8 is approximately El. 421 for pool levels ranging from El. 435 to 438, as noted in Table II. In summer months the average water level is approximately El. 418 for pool levels ranging from El. 424 to 426. Based on the available data (October 1, 1992 through October 31, 1994), the piezometer responded to changes in pool elevation as shown in Figures 14. The small response range of PZ-8 is representative of its location beneath the downstream slope of the embankment and the toe drain that outlets to tail water. The measured water levels in PZ-8 appear to respond somewhat to changes in pool elevation as shown in Figure 26. Based on a linear projection, the water level in the piezometer should rise to El. 424 when the pool reaches the spillway crest, El. 564.

During large changes in pool level, such as the flood event of April 1993, daily readings were taken. The data is presented on an event plot, Figures 17. Based on the flood event shown, the following performance was noted. PZ-8 shows a response time of 4 to 5 days. The longer response time is a result of the piezometer's location downstream of the impervious core. The maximum pool level of the 1993 event, El. 500.9, occurred on 14 April. During this time, the water level in PZ-8 rose about 2 ft from its average winter level to a maximum level of El. 422.9 on 22 April.

(d) Cross Section Evaluation. Representative water level data for "older" (1947) and "newer" (1992) piezometers located at Sta. 17+40 are shown in Figures 28 and 27 respectively.

(1) Station 17+40. As shown in Figures 27 and 28, piezometric levels decrease from the upstream side of the dam towards the downstream toe, with most of the head loss occurring between PZ-5A and 5B and PZ-6A and 6B. The larger decrease, up to 67 ft, illustrates the effectiveness of the cutoff trench and the impervious core. Piezometric levels continue to decrease (2 to 5 ft) beneath the downstream slope between piezometers 6A and 6B and 8. The lower piezometric levels in PZ-7A, 8, A-3 and A-4 and the lack of readings from PZ-7B are consistent with an effective toe drain provided in the design, as shown in Figure 4. The system consists of a pervious fill layer and two 8 in. perforated PVC pipes connected to a manhole located at the toe of the embankment. The manhole discharges to a 12 in. reinforced concrete pipe. The pervious fill layer is approximately 12 ft thick and extends 350 ft upstream from the toe towards the centerline of the embankment. A periodic inspection done in June 1994 stated that the water in the manhole of the toe drain system was slightly higher than the crown of the 12 in. outflow pipe. Attempts to pump the water out of the manhole were made and revealed a constant inflow from the two 8 in. pipes, indicating an operational toe drain system.

Piezometer PZ-B-3, located in the impervious core, was designed to measure pore pressure at the bedrock/soil interface. However, soundings indicate that the tip is located about 10 ft above the design level, inside the impervious core. Nevertheless, the piezometer showed a noticeable response to the flood events in April 93 and again in April 94. The water level in the standpipe rose 40 percent of the pool level increase in April 93. Consequently, PZ-B-3 may still be linked to the underlying bedrock, and/or bedrock may have been locally higher at this location.

PZ-5A and 5B respond in the similar fashion to fluctuations in pool level. Their piezometric levels vary by no more than 0.1 ft. Similar readings may be attributed to an ineffective seal between the two piezometers. Thus, the piezometers no longer monitor separate zones. Instead, they are influenced by the same zone. The lower piezometer, PZ-5A, monitors the piezometric level in the bedrock and the upper

piezometer, PZ-5B monitors the piezometric level in the overburden foundation. The rapid response of both piezometers to fluctuation in pool level may be related to the location of PZ-5A in the bedrock and the influence of the steeply sloping rock beneath the east abutment.

c. Strong Motion Accelerographs.

(1) Data Collection. Waterways Experiment Station (WES) maintains all of NED's strong motion instruments. WES personnel inspect each site twice a year for the purpose of maintenance and repair. A monthly visual inspection by Union Village project personnel is mandatory to check the A-C power inside each shelter and record the electro-mechanical counter reading at each instrument. The findings are recorded on a standard form and mailed each month to the Geotechnical Engineering Division (GED).

In the event of an earthquake and in accordance with ER 1110-2-1802, GED directs Union Village project personnel to read the counter and perform visual inspection of the project. Based on this inspection and the intensity of the event an engineering team may be dispatched to perform a visual inspection and OCE is advised.

After an event, WES is also notified in order to retrieve the earthquake record from the activated accelerographs. GED will also prepare an Earthquake Incident Report on the earthquake event.

(2) Interpretation and Evaluation. In their seventeen year history, the accelerographs at Union Village Dam have experienced five significant seismic events but have only been activated once. The accelerographs were tripped by the Gaza, NH event and the maximum acceleration was 0.05g. The results of the Gaza, NH earthquake event are shown on Table III.

5. Conclusions and Recommendations.

a. General.

Geotechnical instrumentation at Union Village Dam consists of crest survey monuments, piezometers and accelerographs. All the instruments appear to be functioning properly. PZ-5A and 5B appear to be influenced by the same zone. However, they respond together to fluctuations in pool level and are indicative of the groundwater in the area. PZ-5A and 5B show water levels about 6 feet above the pool under normal conditions. These higher readings may be attributed to seepage from the east abutment and are consistent with PZ-B-3 which also has a possible connection to the bedrock. Piezometer 7B was "dry" during the time frame of this report, apparently a result of the piezometer's location within the toe drain of the embankment.

b. Crest Monuments.

(1) Schedule. The schedule for crest monument surveys at Union Village Dam is presently once every five years, which coincides with the periodic inspection schedule. If unusual readings are obtained during the next survey, or if field evidence of embankment movement manifests itself, the monitoring schedule will be adjusted as required.

(2) Evaluation of Adequacy. Between 1973 and 1994, the maximum measured settlement was 0.07 ft (0.8 in.). Although small, the settlement appears to be developing linear with time and in proportion to the height of the embankment. This small amount of settlement is considered tolerable. During the next field survey, the accuracy of the procedures, the reliability and condition of the monuments and control points should be confirmed. Also during the next survey, it is recommended to

establish permanent elevation benchmarks on the gate house and on the spillway training wall to provide additional reliable elevation control.

There is no physical evidence of horizontal movement of the dam. Third order accuracy is presently the standard utilized to perform all crest monument surveys and is considered adequate at this time. With the advent of a Global Positioning System Survey (GPSS) such as NAVSTAR, (which utilizes signals bounced off satellites) the accuracy of three dimensional movements can be detected at a level of less than 5 millimeters (Ref. ETL 1110-1-133). The implementation of this type of monitoring is recommended within the next 5 to 10 years provided it proves to be cost effective.

c. Piezometers.

(1) Reading Schedule. The current piezometer reading schedule as outlined in paragraph 4.b.1.a of this report should continue to be implemented by project personnel.

(2) Evaluation of Adequacy. The piezometer data manipulation and plots show the seepage patterns within the embankment and foundation of Union Village Dam. The piezometer plots indicate that most of the head loss occurring in the dam, takes place across the impervious core and cutoff trench.

Based on the data collected to date, the piezometers appear to be functioning correctly with the exception of PZ-5A and 5B which appear to be influenced by the same zone but are still responsive to fluctuations in pool level. The present number and configuration of piezometers is adequate to evaluate the pore pressures affecting the dam.

d. Strong Motion Accelerographs.

(1) General. Since their installation in 1978, the strong motion accelerographs at Union Village Dam have only experienced five significant earthquakes and were activated once in 1982 by the Gaza, NH earthquake. The records from this event showed a maximum acceleration of 0.05g (accelerograph at downstream toe of dam).

(2) Reading Schedule. The present schedule for reading all strong motion accelerographs at Union Village Dam is once per month.

In the past, this schedule has been maintained very well and there is a very good data base of information for accelerographs. The present schedule is adequate and should be maintained.

(3) Evaluation of Adequacy. The present level of strong motion instrumentation is adequate to monitor motion of the dam and foundation in the event of an earthquake. The maintenance of current equipment is recommended and no supplement accelerographs are recommended at this time.

TABLE I
PIEZOMETER SUMMARY
UNION VILLAGE DAM

PIEZOMETER NUMBER	APPROXIMATE STATION	APPROXIMATE CENTELINE OFFSET	RISER PIPE TOP ELEVATION	PIEZOMETER TIP ELEVATION	ZONE LOCATED	MATERIAL AT TIP ELEVATION
PZ-5A	17+40	105 U/S	552.0	398.0	FOUNDATION	Bedrock
PZ-5B	17+40	105 U/S	552.0	410.0	RANDOM FILL	Olive br. silty (15-25) SAND (SM)
PZ-6A	17+40	30 D/S	579.0	405.0	FOUNDATION	Olive br. silty (25.5) SAND w/ gravel (22.8) (SP-SM)
PZ-6B	17+40	30 D/S	579.0	418.8	IMPERVIOUS CORE	Olive br. SILT(ML)
PZ-7A	17+40	225 D/S	513.0	399.2	FOUNDATION	Very dk. grayish br. silty (18.4) SAND w/ gravel (27.4) (SM)
PZ-7B	17+40	225 D/S	513.0	420.0	PERVIOUS FILL	Olive br. poorly graded SAND w/ silt (11.1) and gravel (19.9) (SP-SM)
PZ-8	17+40	450 D/S	440.0	386.9	FOUNDATION/RANDOM FILL	Olive br. silty (15-25) SAND w/ gravel (25-35) (SM)
PZ-A-3	17+40	150 D/S	536.7	416.0*	FOUNDATION/PERV. FILL	Pervious sand (SP-SM, SP, SM)
PZ-A-4	17+40	300 D/S	486.7	417.7*	FOUNDATION	Pervious sand (SP-SM, SP)
PZ-B-3	17+40	10 D/S	585.0	414.5*	FOUNDATION	Pervious foundation soils

Notes:

1. All elevations in feet and referenced to National Geodetic Vertical Datum (NGVD).
2. * Piezometer tip elevation corresponds to sounding elevation performed in 1988.

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TABLE II
PIEZOMETER WATER ELEVATIONS
UNION VILLAGE DAM

DATE	STAGE	POOL EL.	PIEZOMETRIC LEVEL (FT - NGVD)											
			PZ 5A	PZ 5B	PZ A-3	PZ A-4	PZ 6A	PZ 6B	PZ B-3	PZ 7A	PZ 7B	PZ 8		
01-Oct-92	6.0	426.0	430.0	429.9	DRY	DRY	417.9	DRY	416.0	418.0	DRY	417.0		
06-Nov-92	5.1	425.1	431.0	430.9	DRY	DRY	418.9	DRY	417.0	419.0	DRY	418.0		
30-Nov-92	10.3	430.3	430.4	430.3	DRY	DRY	418.4	DRY	417.0	418.0	DRY	417.3		
04-Jan-93	17.0	437.0	430.1	430.0	DRY	DRY	418.1	DRY	416.7	417.6	DRY	417.0		
29-Jan-93	18.6	438.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		
01-Mar-93	11.9	431.9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		
31-Mar-93	59.8	479.8	464.0	463.9	420.7	418.7	421.9	426.9	448.0	420.0	DRY	419.0		
05-Apr-93	22.9	442.9	455.4	455.3	421.7	420.2	421.9	426.0	441.6	421.7	DRY	420.0		
06-Apr-93	16.5	436.5	447.1	447.0	422.1	420.2	422.0	426.0	441.6	421.7	DRY	420.0		
07-Apr-93	15.0	435.0	447.0	446.9	421.7	419.7	421.9	425.9	441.1	421.1	DRY	419.6		
08-Apr-93	14.7	434.7	442.5	442.4	422.7	420.7	422.4	425.4	438.0	422.0	DRY	420.5		
09-Apr-93	16.7	436.7	442.0	441.9	422.7	420.7	422.4	425.4	438.0	422.0	DRY	420.5		
10-Apr-93	22.9	442.9	439.0	438.9	423.2	420.3	421.9	424.9	438.5	422.5	DRY	421.0		
11-Apr-93	47.2	467.2	455.5	455.4	421.7	420.2	421.9	426.9	448.0	422.0	DRY	420.0		
12-Apr-93	68.4	488.4	481.0	480.9	420.7	418.7	422.9	427.4	452.0	420.0	DRY	419.0		
13-Apr-93	78.7	498.7	494.0	493.9	423.2	421.2	422.9	428.9	455.5	422.5	DRY	421.0		
14-Apr-93	80.9	500.9	495.0	494.9	423.7	421.7	423.4	429.9	456.0	423.0	DRY	421.5		
15-Apr-93	76.4	496.4	495.0	494.9	423.7	421.7	423.9	430.9	456.0	422.5	DRY	421.0		
16-Apr-93	67.7	487.7	487.0	486.9	423.7	421.7	423.9	432.4	456.0	423.5	DRY	421.0		
17-Apr-93	65.3	485.3	487.5	487.4	423.7	421.7	424.4	432.9	455.5	423.0	DRY	421.0		
18-Apr-93	75.9	495.9	494.0	493.9	425.0	423.2	424.6	432.0	457.3	424.5	DRY	422.1		
19-Apr-93	72.9	492.9	491.6	491.5	424.7	422.7	424.9	432.9	457.6	424.4	DRY	422.0		
20-Apr-93	64.0	484.0	487.5	487.4	423.7	421.7	424.9	432.9	455.5	423.0	DRY	421.0		
21-Apr-93	49.8	469.8	472.5	472.5	425.5	423.0	425.4	432.7	457.3	424.7	DRY	422.1		
22-Apr-93	37.0	457.0	462.3	462.2	425.7	423.0	432.0	425.3	457.1	424.8	DRY	422.9		
23-Apr-93	33.0	453.0	462.7	462.6	426.2	423.5	432.9	425.9	457.8	425.0	DRY	422.0		
24-Apr-93	39.8	459.8	460.8	460.7	425.7	423.0	432.9	430.4	456.5	424.6	DRY	422.0		
25-Apr-93	23.7	443.7	451.7	451.9	426.6	423.0	432.9	430.1	456.9	424.6	DRY	422.9		
26-Apr-93	15.4	435.4	443.0	442.4	425.7	420.7	425.4	427.4	454.0	424.0	DRY	421.1		
29-Apr-93	12.0	432.0	440.0	439.9	425.7	421.7	425.4	427.4	454.0	424.0	DRY	421.1		
30-Apr-93	11.6	431.6	438.0	437.9	425.2	422.7	424.4	426.9	455.0	424.0	DRY	421.7		
03-May-93	12.0	432.0	437.5	437.4	424.7	422.2	423.9	426.4	454.5	423.5	DRY	421.0		
01-Jun-93	9.5	429.5	437.0	436.9	424.7	421.7	423.9	425.9	454.0	423.0	DRY	421.0		
30-Jun-93	4.5	424.5	432.6	432.5	420.7	418.7	419.9	420.9	427.5	419.6	DRY	418.5		
02-Aug-93	3.8	423.8	430.7	430.6	418.7	416.7	418.9	420.4	424.1	418.0	DRY	416.5		
01-Sep-93	4.1	424.1	431.1	431.0	419.1	417.0	419.4	420.9	424.6	419.3	DRY	417.0		
06-Oct-93	5.4	425.4	430.6	430.5	418.8	416.7	419.4	420.3	424.2	418.8	DRY	416.3		
01-Nov-93	6.6	426.6	430.2	430.1	418.7	416.4	419.1	420.0	424.0	418.4	DRY	416.1		
01-Dec-93	21.3	441.3	462.1	462.0	425.4	422.8	431.8	425.0	457.0	425.0	DRY	421.7		

TABLE II
PIEZOMETER WATER ELEVATIONS
UNION VILLAGE DAM

DATE	STAGE	POOL EL.	PIEZOMETRIC LEVEL (FT. - NGVD)													
			PZ 5A	PZ 5B	PZ A-3	PZ A-4	PZ 6A	PZ 6B	PZ B-3	PZ 7A	PZ 7B	PZ 8				
03-Jan-94	NA	420.0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
02-Feb-94	NA	420.0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
01-Mar-94	16.3	436.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
01-Apr-94	23.5	443.5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR				
08-Apr-94	40.0	460.0	454.0	453.9	422.7	420.7	411.9	424.9	436.0	422.0	422.0	418.0				
09-Apr-94	26.0	446.0	454.1	454.0	422.4	420.4	411.5	424.5	435.6	421.7	421.7	417.8				
10-Apr-94	17.4	437.4	453.8	453.7	422.1	420.3	411.6	424.7	435.4	421.6	421.6	417.7				
11-Apr-94	20.2	440.2	441.4	440.9	423.2	420.7	422.9	421.9	431.6	422.0	422.0	421.0				
12-Apr-94	18.1	438.1	441.2	441.1	423.4	420.3	421.9	420.9	431.4	421.4	421.4	420.4				
13-Apr-94	22.0	442.0	442.0	441.9	422.7	417.7	422.9	425.5	432.1	421.0	421.0	420.0				
14-Apr-94	36.0	456.0	450.0	449.9	423.8	421.5	422.9	425.9	434.1	423.0	423.0	421.0				
15-Apr-94	63.2	483.2	470.5	470.4	424.0	421.7	423.4	426.7	443.0	423.2	423.2	421.2				
16-Apr-94	67.2	487.2	480.9	481.1	423.9	421.9	423.8	428.0	452.4	423.4	423.4	421.3				
17-Apr-94	73.0	493.0	468.9	468.5	424.3	422.0	424.8	428.9	454.9	423.6	423.6	421.4				
18-Apr-94	68.7	488.7	487.2	486.9	424.6	422.2	430.6	429.5	428.3	423.8	423.8	421.6				
19-Apr-94	60.2	480.2	480.5	480.1	424.8	422.5	424.6	430.0	454.3	424.0	424.0	421.8				
20-Apr-94	53.0	473.0	474.1	473.8	420.1	422.7	424.7	429.9	454.6	424.2	424.2	421.8				
21-Apr-94	34.3	454.3	466.0	465.4	425.0	422.6	424.9	429.5	454.0	424.0	424.0	421.8				
22-Apr-94	29.0	449.0	455.8	455.9	425.3	421.9	424.9	429.1	451.4	424.4	424.4	421.8				
23-Apr-94	15.8	435.8	447.0	446.9	425.4	422.8	424.9	428.9	450.2	424.5	424.5	421.9				
24-Apr-94	15.5	435.5	446.4	446.3	425.2	422.9	424.7	428.3	450.1	424.2	424.2	421.8				
25-Apr-94	15.1	435.1	447.0	446.9	425.4	422.9	424.9	428.6	450.3	424.4	424.4	421.9				
26-Apr-94	15.5	435.5	446.7	446.6	425.6	423.1	424.9	428.8	450.5	424.6	424.6	422.0				
02-May-94	15.1	435.1	446.9	446.8	425.5	422.7	424.7	428.4	450.1	424.4	424.4	422.0				
02-Jun-94	6.0	426.0	433.4	433.7	DRY	420.5	421.9	422.7	430.6	421.6	421.6	420.0				
06-Jul-94	4.4	424.4	432.5	432.4	420.7	418.7	419.6	420.6	427.5	419.3	419.3	419.5				
01-Aug-94	4.0	424.0	431.6	431.7	DRY	DRY	419.3	DRY	425.0	419.0	419.0	418.1				
02-Sep-94	4.0	424.0	431.9	431.1	DRY	DRY	418.9	DRY	424.4	418.4	418.4	418.0				
04-Oct-94	5.8	425.8	431.4	431.9	DRY	DRY	419.1	DRY	425.0	418.0	418.0	417.9				
31-Oct-94	4.6	424.6	430.6	431.0	DRY	DRY	458.4	DRY	424.1	417.0	417.0	417.0				
AVG. LEVEL DURING WINTER POOL			444.4	444.3	423.9	421.4	422.2	426.1	440.1	422.4	422.4	420.6				
AVG. LEVEL DURING SUMMER POOL			431.2	431.3	419.6	417.6	419.2	420.6	423.6	418.6	418.6	417.6				

NOTES:

1. NA - READING NOT AVAILABLE, NR - READING NOT TAKEN DUE TO WEATHER, DRY - NO WATER LEVEL READ IN PIEZOMETER
2. AVERAGE WINTER WATER LEVEL FOR PIEZOMETERS IS BASED ONLY ON READINGS WHEN THE POOL ELEVATION FALLS BETWEEN EL. 435 AND 438.
3. AVERAGE SUMMER WATER LEVEL FOR PIEZOMETERS IS BASED ONLY ON READINGS WHEN THE POOL ELEVATION FALLS BETWEEN EL. 424 AND 426.

JULY 1995

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TABLE II
PIEZOMETER WATER DEPTHS
UNION VILLAGE DAM

DATE	STAGE	POOL EL.	DEPTH (FEET)									
			PZ 5A	PZ 5B	PZ A-3	PZ A-4	PZ 6A	PZ 6B	PZ B-3	PZ 7A	PZ 7B	PZ 8
01-Oct-92	6.0	426.0	124.0	124.0	DRY	DRY	163.0	DRY	169.0	101.0	DRY	33.0
06-Nov-92	5.1	425.1	123.0	123.0	DRY	DRY	162.0	DRY	168.0	100.0	DRY	32.0
30-Nov-92	10.3	430.3	123.6	123.6	DRY	DRY	162.5	DRY	168.0	101.0	DRY	32.7
04-Jan-93	17.0	437.0	123.9	123.9	DRY	DRY	162.8	DRY	168.3	101.4	DRY	33.0
29-Jan-93	18.6	438.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
01-Mar-93	11.9	431.9	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
31-Mar-93	59.8	479.8	90.0	90.0	116.0	68.0	NR	NR	NR	99.0	DRY	31.0
05-Apr-93	22.9	442.9	98.6	98.6	115.0	66.5	159.0	154.0	137.0	97.0	DRY	30.0
06-Apr-93	16.5	436.5	106.9	106.9	114.6	66.5	158.9	154.9	143.4	97.3	DRY	30.0
07-Apr-93	15.0	435.0	107.0	107.0	115.0	67.0	159.0	155.0	143.9	97.9	DRY	30.4
08-Apr-93	14.7	434.7	111.5	111.5	114.0	66.0	158.5	155.5	147.0	97.0	DRY	29.5
09-Apr-93	16.7	436.7	112.0	112.0	114.0	66.0	158.5	155.5	147.0	97.0	DRY	29.5
10-Apr-93	22.9	442.9	115.0	115.0	113.5	66.4	159.0	156.0	146.5	96.5	DRY	29.0
11-Apr-93	47.2	467.2	98.5	98.5	115.0	66.5	159.0	154.0	137.0	97.0	DRY	30.0
12-Apr-93	68.4	488.4	73.0	73.0	116.0	68.0	158.0	153.5	133.0	99.0	DRY	31.0
13-Apr-93	78.7	498.7	60.0	60.0	113.5	65.5	158.0	152.0	129.5	96.5	DRY	29.0
14-Apr-93	80.9	500.9	59.0	59.0	113.0	65.0	157.5	151.0	129.0	96.0	DRY	28.5
15-Apr-93	76.4	496.4	59.0	59.0	113.5	65.0	157.0	150.0	129.0	96.5	DRY	29.0
16-Apr-93	67.7	487.7	67.0	67.0	113.0	65.0	157.0	148.5	129.0	95.5	DRY	29.0
17-Apr-93	65.3	485.3	66.5	66.5	113.0	65.0	156.5	148.0	129.5	96.0	DRY	29.0
18-Apr-93	75.9	495.9	60.0	60.0	111.7	63.5	156.3	148.9	127.7	94.5	DRY	27.9
19-Apr-93	72.9	492.9	62.4	62.4	112.0	64.0	156.0	148.0	127.4	94.6	DRY	28.0
20-Apr-93	64.0	484.0	66.5	66.5	113.0	65.0	156.0	148.0	129.5	96.0	DRY	29.0
21-Apr-93	49.8	469.8	81.5	81.4	111.2	63.7	155.5	148.2	127.8	94.3	DRY	27.9
22-Apr-93	37.0	457.0	91.7	91.7	110.5	63.7	148.9	155.6	127.9	94.2	DRY	27.1
23-Apr-93	33.0	453.0	91.3	91.3	110.5	63.2	148.0	155.0	127.2	94.0	DRY	28.0
24-Apr-93	39.8	459.8	93.2	93.2	111.0	63.7	155.9	150.5	128.5	94.4	DRY	28.0
25-Apr-93	23.7	443.7	102.3	102.0	110.1	63.7	155.9	150.8	128.1	94.4	DRY	27.1
26-Apr-93	15.4	435.4	111.0	111.5	111.0	66.0	158.0	155.0	148.0	98.0	DRY	28.0
29-Apr-93	12.0	432.0	114.0	114.0	111.0	65.0	155.5	153.5	131.0	95.0	DRY	28.9
30-Apr-93	11.6	431.6	116.0	116.0	111.5	64.0	156.5	154.0	130.0	95.0	DRY	28.3
03-May-93	12.0	432.0	116.5	116.5	112.0	64.5	157.0	154.5	130.5	95.5	DRY	29.0
01-Jun-93	9.5	429.5	117.0	117.0	112.0	65.0	157.0	155.0	131.0	96.0	DRY	29.0
30-Jun-93	4.5	424.5	121.4	121.4	116.0	68.0	161.0	160.0	157.5	99.4	DRY	31.5
02-Aug-93	3.8	423.8	123.3	123.3	118.0	70.0	162.0	160.5	160.9	101.0	DRY	33.5
01-Sep-93	4.1	424.1	122.9	122.9	117.6	69.7	161.5	160.0	160.4	99.7	DRY	33.0
06-Oct-93	5.4	425.4	123.4	123.4	117.9	70.0	161.5	160.6	160.8	100.2	DRY	33.7
01-Nov-93	6.6	426.6	123.8	123.8	118.0	70.3	161.8	160.9	161.0	100.6	DRY	33.9
01-Dec-93	21.3	441.3	91.9	91.9	111.3	63.9	149.1	155.9	128.0	94.0	DRY	28.3

TABLE II
PIEZOMETER WATER DEPTHS
UNION VILLAGE DAM

DATE	STAGE	POOL EL.	DEPTH (FEET)											
			PZ 5A	PZ 5B	PZ A-3	PZ A-4	PZ 6A	PZ 6B	PZ B-3	PZ 7A	PZ 7B	PZ 8		
03-Jan-94	NA	420.0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
02-Feb-94	NA	420.0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
01-Mar-94	16.3	436.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
01-Apr-94	23.5	443.5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
08-Apr-94	40.0	460.0	100.0	100.0	114.0	66.0	169.0	156.0	149.0	97.0	DRY	DRY	32.0	32.0
09-Apr-94	26.0	446.0	99.9	99.9	114.3	66.3	169.4	156.4	149.4	97.3	DRY	DRY	32.2	32.2
10-Apr-94	17.4	437.4	100.2	100.2	114.6	66.4	169.3	156.2	149.6	97.4	DRY	DRY	32.3	32.3
11-Apr-94	20.2	440.2	112.6	113.0	113.5	66.0	158.0	159.0	153.4	97.0	DRY	DRY	29.0	29.0
12-Apr-94	18.1	438.1	112.8	112.8	113.3	66.4	159.0	160.0	153.6	97.6	DRY	DRY	29.6	29.6
13-Apr-94	22.0	442.0	112.0	112.0	114.0	69.0	158.0	155.4	152.9	96.0	DRY	DRY	30.0	30.0
14-Apr-94	36.0	456.0	104.0	104.0	112.9	65.2	158.0	155.0	150.9	95.8	DRY	DRY	29.0	29.0
15-Apr-94	63.2	483.2	83.5	83.5	112.7	65.0	157.5	154.2	142.0	95.8	DRY	DRY	28.8	28.8
16-Apr-94	67.2	487.2	73.1	72.8	112.8	64.8	157.1	152.9	132.6	95.6	DRY	DRY	28.7	28.7
17-Apr-94	73.0	493.0	85.1	85.4	112.4	64.7	156.1	152.0	130.1	95.4	DRY	DRY	28.6	28.6
18-Apr-94	68.7	488.7	66.8	67.0	112.1	64.5	150.3	151.4	156.7	95.2	DRY	DRY	28.4	28.4
19-Apr-94	60.2	480.2	73.5	73.8	111.9	64.2	156.3	150.9	130.7	95.0	DRY	DRY	28.2	28.2
20-Apr-94	53.0	473.0	79.9	80.1	116.6	64.0	156.2	151.0	130.4	94.8	DRY	DRY	28.2	28.2
21-Apr-94	34.3	454.3	88.0	88.5	111.7	64.1	156.0	151.4	131.0	95.0	DRY	DRY	28.2	28.2
22-Apr-94	29.0	449.0	98.2	98.0	111.4	64.8	156.0	151.8	133.6	94.6	DRY	DRY	28.2	28.2
23-Apr-94	15.8	435.8	107.0	107.0	111.3	63.9	156.0	152.0	134.8	94.5	DRY	DRY	28.1	28.1
24-Apr-94	15.5	435.5	107.6	107.6	111.5	63.9	156.2	152.6	134.9	94.8	DRY	DRY	28.2	28.2
25-Apr-94	15.1	435.1	107.0	107.0	111.3	63.8	156.0	152.3	134.7	94.6	DRY	DRY	28.1	28.1
26-Apr-94	15.5	435.5	107.3	107.3	111.1	63.6	156.0	152.1	134.5	94.4	DRY	DRY	28.0	28.0
02-May-94	15.1	435.1	107.1	107.1	111.2	64.0	156.2	152.5	134.9	94.6	DRY	DRY	30.0	30.0
02-Jun-94	6.0	426.0	120.6	120.2	DRY	66.2	159.0	158.2	154.4	97.4	DRY	DRY	30.5	30.5
06-Jul-94	4.4	424.4	121.5	121.5	116.0	68.0	161.3	160.3	157.5	99.7	DRY	DRY	31.9	31.9
01-Aug-94	4.0	424.0	122.4	122.2	DRY	DRY	161.6	DRY	160.0	100.0	DRY	DRY	32.0	32.0
02-Sep-94	4.0	424.0	122.1	122.8	DRY	DRY	162.0	DRY	160.6	100.6	DRY	DRY	32.1	32.1
04-Oct-94	5.8	425.8	122.6	122.0	DRY	DRY	161.8	DRY	160.0	101.0	DRY	DRY	32.1	32.1
31-Oct-94	4.6	424.6	123.4	122.9	DRY	DRY	122.5	DRY	160.9	102.0	DRY	DRY	33.0	33.0

NOTES:

1. NA - READING NOT AVAILABLE, NR - READING NOT TAKEN DUE TO WEATHER, DRY - NO WATER LEVEL READ IN PIEZOMETER

JULY 1995

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TABLE III
HISTORIC SEISMIC DATA
UNION VILLAGE DAM

SEISMIC EVENT	DISTANCE TO CENTER	INTENSITY * AT CENTER	RECORDED ACCELERATION AT DAM	ESTIMATED ACCELERATION AT DAM
Grand Falls, N.B., Canada (1/09/82)	306 mi.	7.4 (R = 5.8)	N/A	N/A
Gaza, New Hampshire (1/19/82)	11 mi.	5.2 (R = 4.7)	0.05g	N/A
Blue Mountain, New York (10/07/83)	130 mi.	6.0 (R = 5.1)	N/A	N/A
Franklin, New Hampshire (10/25/86)	5 mi.	3.6 (R = 3.9)	N/A	N/A
Saguenay, Quebec, Canada (11/25/88)	250 mi.	7.6 (R = 5.9)	N/A	N/A

* Intensities correspond to Modified Mercalli Intensity (MMI) = (2 x Richter Magnitude) - 4.2

N/A = Accelerographs not activated

JULY 1995

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FILE NO. 11163-006 A53

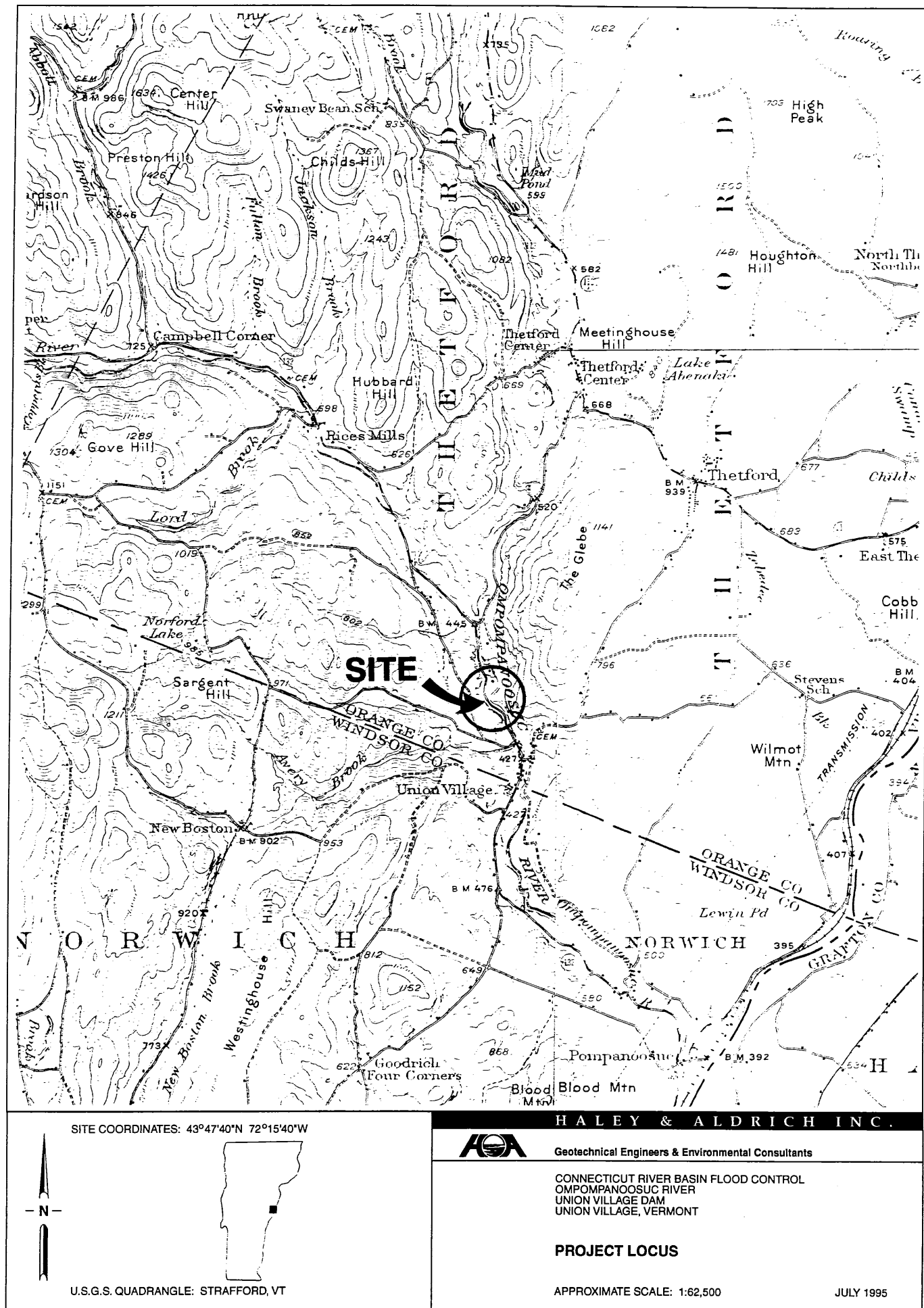
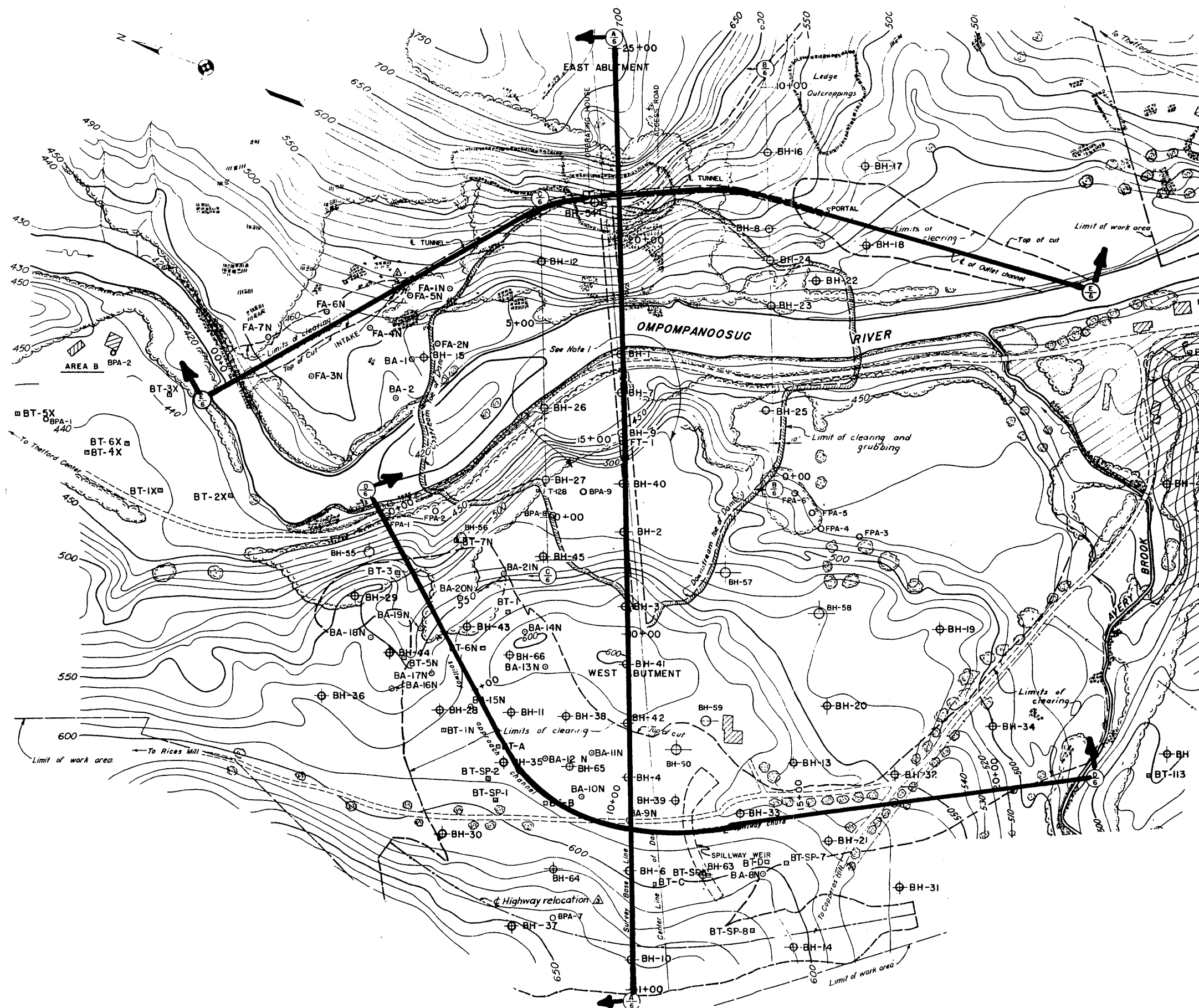


FIGURE 1



NOTES

1. Area in this vicinity used as borrow source by Vermont State Highway Dept. Topography subject to change.
2. For log of explorations, see Sheets No. 7, 8, 9a, 8b, & 9c.
3. Subsurface investigations by means of core borings, auger borings and test pits have been made at the sites of the dam and appurtenances. The logs and samples pertaining to these investigations may be inspected at the United States Engineer Field Office at the site of the work.
4. Contour interval, 10 feet.
5. All elevations refer to Mean Sea Level Datum.
6. The entire work area is shown on Sheet No. 4.
7. Excavated materials from spillway approach channel were used for impervious and random embankment construction.
8. The data contained hereon are not intended as representations or warranties but are furnished for information only. It is expressly understood that the government was not responsible for any deduction, interpretation, or conclusion therefrom made by any bidder or contractor.

LEGEND

- BT-114
- BA - Borrow auger boring
- BH - Drive sample boring-overburden sampled by driving spoon and bedrock cored by diamond bit.
- BPA - Borrow power auger boring
- BT - Borrow test pit
- FA - Foundation auger boring
- FPA - Foundation power auger boring
- FT - Foundation test pit
- Existing roads
- Outline of Structures and excavations
- Buildings
- Rock outcrops
- Limit of wooded areas

EXPLANATION OF SECTION DESIGNATION

The section designations used are represented by fractions, the numerator of which is the section reference and the denominator the sheet number on which the section is taken or shown. Example: Section B is taken on Sheet No. 5 and the section is actually shown on Sheet No. 6. On Sheet No. 5 the section reference would be noted $\frac{B}{5}$ and on Sheet No. 6 the section would be noted $\frac{B}{6}$.

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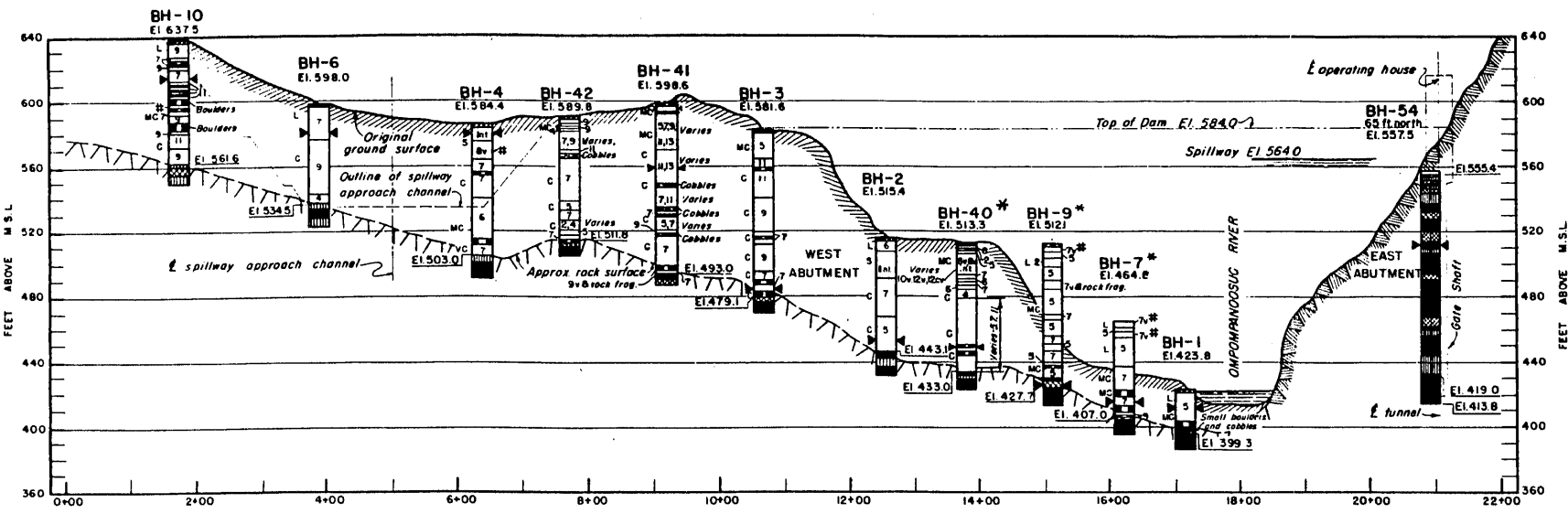
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

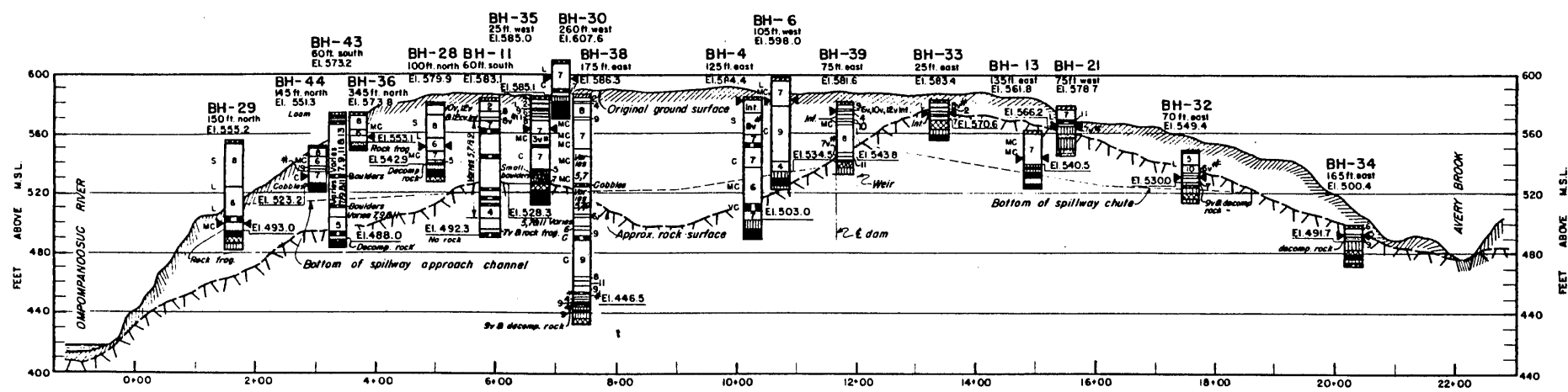
AS BUILT PLAN

SCALE: AS SHOWN

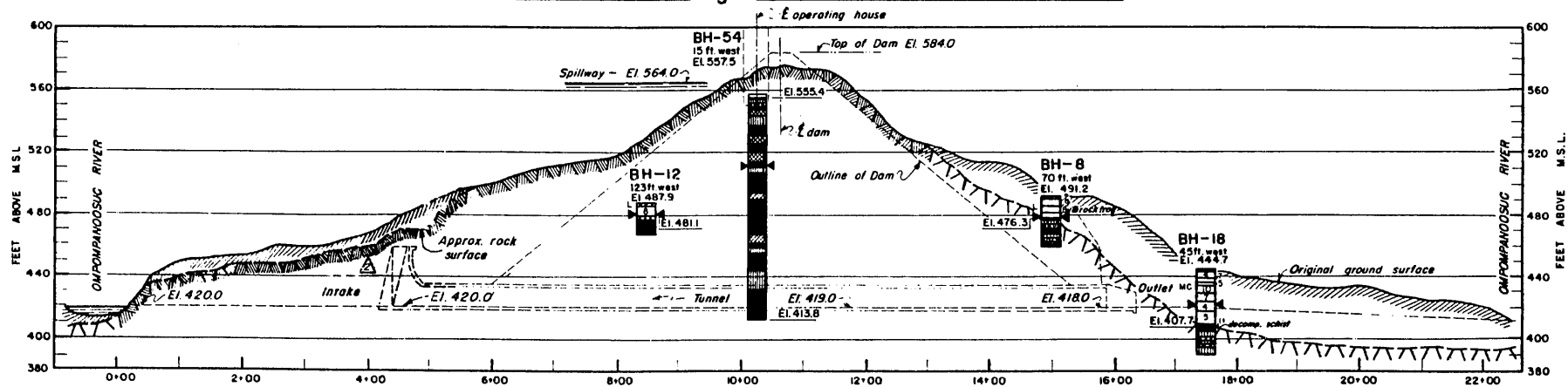
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SECTION ON LINE $\frac{A}{5}$ LOOKING UPSTREAM



PROFILE ON LINE $\frac{D}{5}$ OF SPILLWAY LOOKING TOWARD DAM



PROFILE ON CENTER LINE OF TUNNEL $\frac{E}{5}$

- DESCRIPTION OF SOIL CLASSES**
- 1 Graded from Gravel to Coarse Sand - Contains little medium sand.
 - 2 Coarse to Medium Sand - Contains little gravel and fine sand.
 - 3 Graded from Gravel to Medium Sand - Contains little fine sand.
 - 4 Medium to Fine Sand - Contains little coarse sand and coarse silt.
 - 5 Graded from Gravel to Fine Sand - Contains little coarse silt.
 - 6 Fine Sand to Coarse Silt - Contains little medium sand and medium silt.
 - 7 Graded from Gravel to Coarse Silt - Contains little medium silt.
 - 8 Coarse to Medium Silt - Contains little fine sand and fine silt.
 - 9 Graded from Gravel to Medium Silt - Contains little fine silt.
 - 10 Medium to Fine Silt - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
 - 10C Medium Silt to Coarse Clay - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
 - 11 Graded from Gravel or Coarse Sand to Fine Silt - Contains little coarse clay.
 - 12 Fine Silt to Clay - Contains little medium silt and fine clay (colloidal). Possesses behavior characteristics of silt.
 - 12C Clay - Contains little silt. Possesses behavior characteristics of clay.
 - 13 Graded from Coarse Sand to Clay - Contains little fine clay (colloidal). Possesses behavior characteristics of silt.
 - 13C Clay - Graded from sand to fine clay (colloidal). Possesses behavior characteristics of clay.

- LEGEND**
- Water table
 - Rock Core Recovery 0-15%
 - Rock Core Recovery 16-50%
 - Rock Core Recovery 51-75%
 - Rock Core Recovery greater than 75%
 - Classification number obtained by laboratory test.
 - Classification number obtained by visual inspection
 - Topsoil
 - Boulder
 - BH - Drive sample boring - overburden sampled by driving spoon and bedrock cored by diamond bit.
 - Rock frag - rock fragments.

NOTES

* Location now used as active gravel pit.
 Rock formation is composed of steeply inclined beds of dark fine grained schist which have a strongly developed slaty cleavage structure similarly inclined.
 Elevations refer to Mean Sea Level Datum.
 For location of profile and sections, see Sheet No. 5.
 Center lines of graphic logs coincide with those of bore holes.
 For location of bore holes, see Sheet No. 4.
 For log of bore holes, see Sheets Nos. 2, 8, 8A, 8B and 8C.
 L - loose, MC - medium compact, C - compact, VC - very compact, Int. - interstratified.
 * Sample uncertain, sampled by wash boring or other non-representative method.
 More complete sample descriptions, in the boring logs, and test results pertaining to the above investigations, as well as the samples, may be inspected at the United States Field Office at the site of the work.

The data contained hereon are not intended as representations or warranties but are furnished for information only. It is expressly understood that the Government was not responsible for any deduction, interpretation or conclusion therefrom made by any bidder or Contractor.
 Explorations indicated on this sheet were completed in 1937 and 1938.

NOTES:

1. DRAWING PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.

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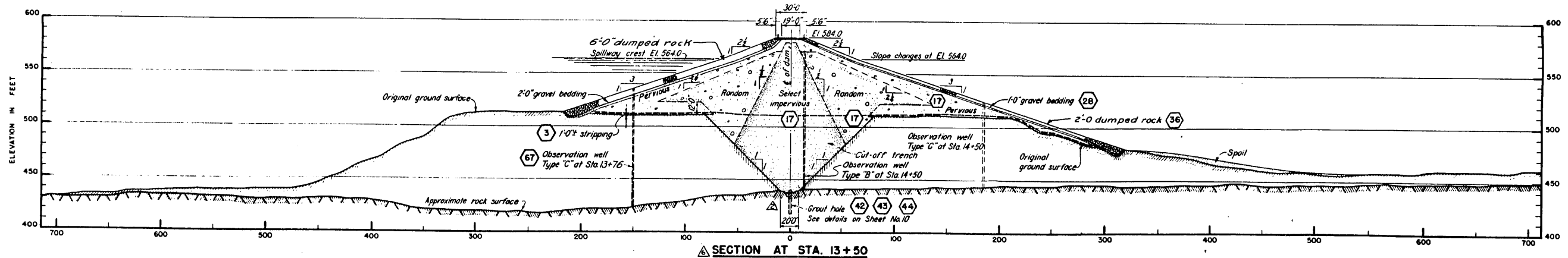
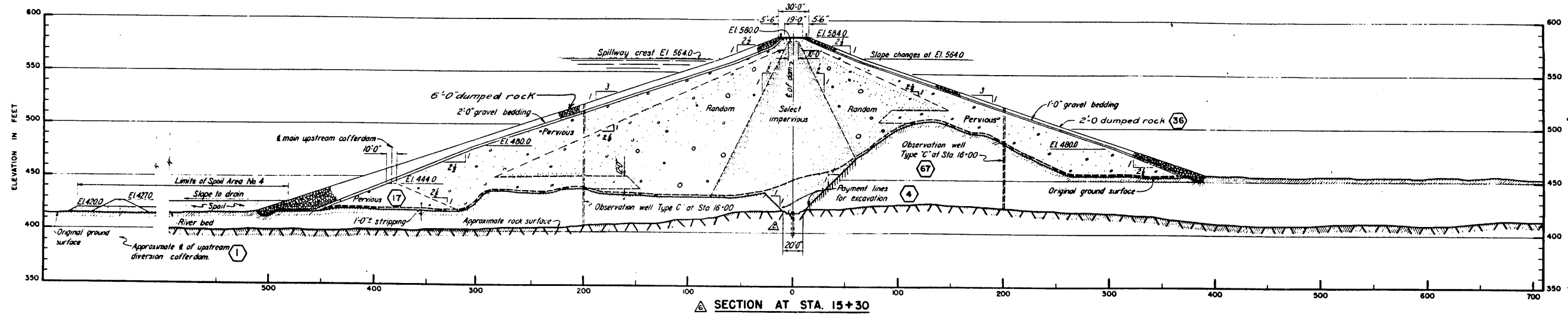
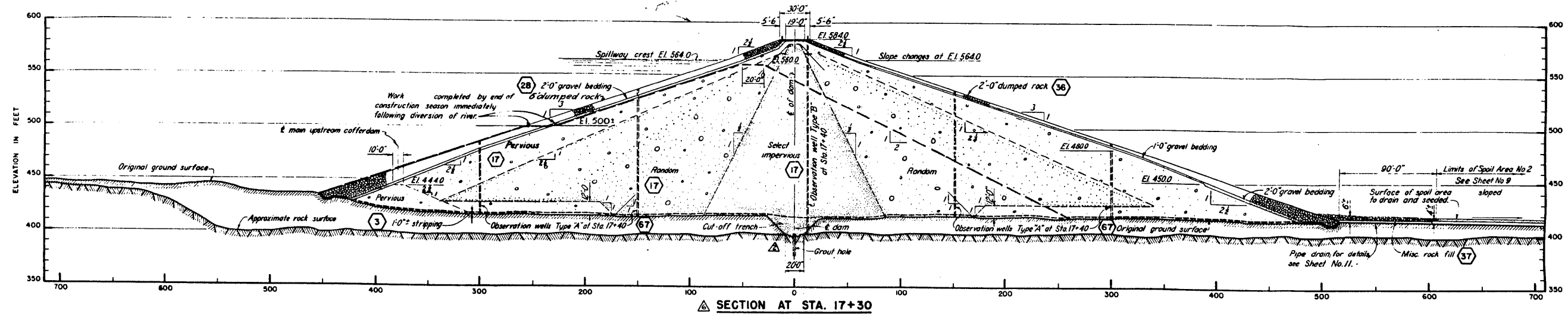
CONNECTICUT RIVER BASIN FLOOD CONTROL
 OMPOMPAOOSUC RIVER
 UNION VILLAGE DAM
 UNION VILLAGE, VERMONT

AS BUILT PROFILES

SCALE: AS SHOWN

JULY 1995

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NOTES:

1. DRAWING PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.



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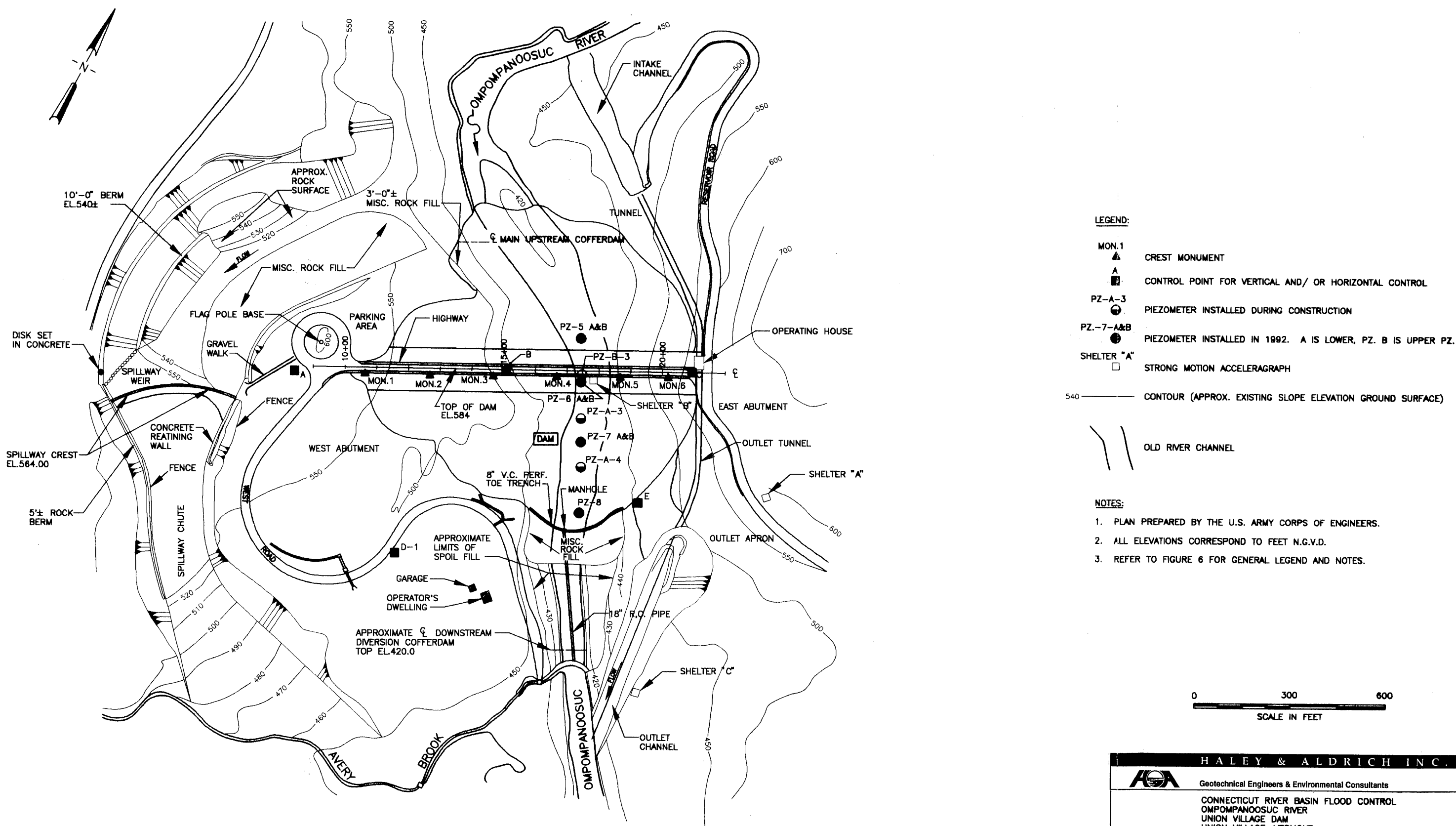
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

AS BUILT CROSS SECTIONS

SCALE: AS SHOWN

JULY 1995



0 300 600
SCALE IN FEET

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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

INSTRUMENTATION PLAN

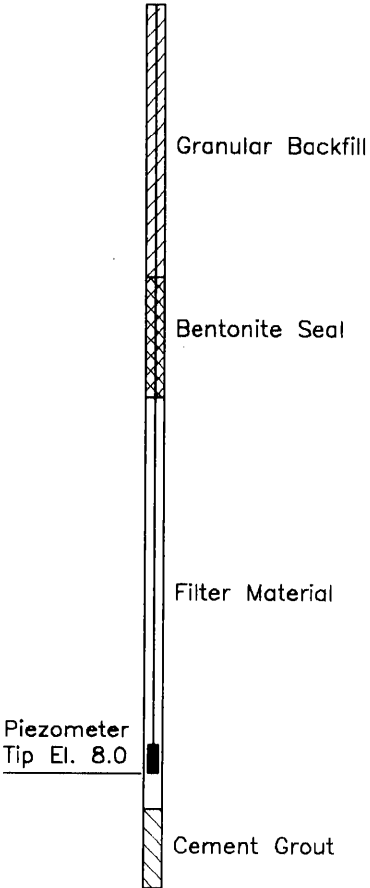
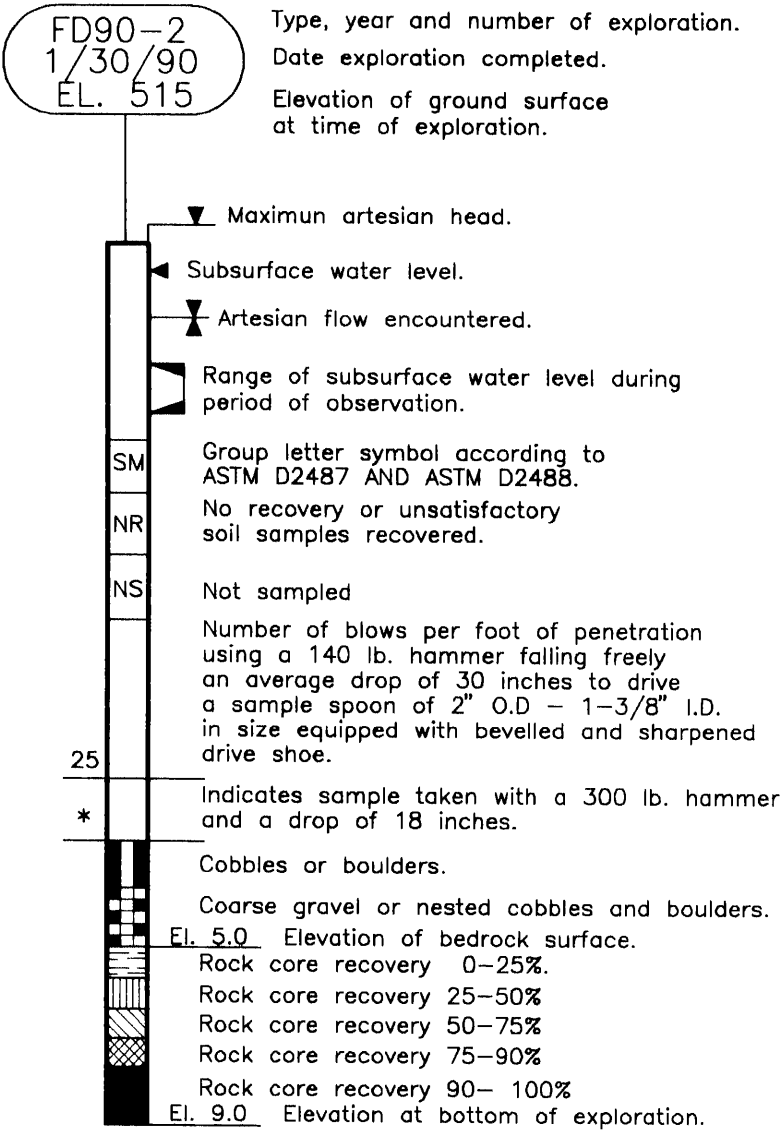
SCALE: 1" = 300'

JULY 1995

FIGURE 5


LEGEND FOR GRAPHIC LOGS

LEGEND FOR PIEZOMETER



Boring Number	Piezometer Number
FD-92-1	PZ-8
FD-92-2	PZ-7A
FD-92-2	PZ-7B
FD-92-3	PZ-6A
FD-92-3	PZ-6B
FD-92-4	PZ-5A
FD-92-4	PZ-5B

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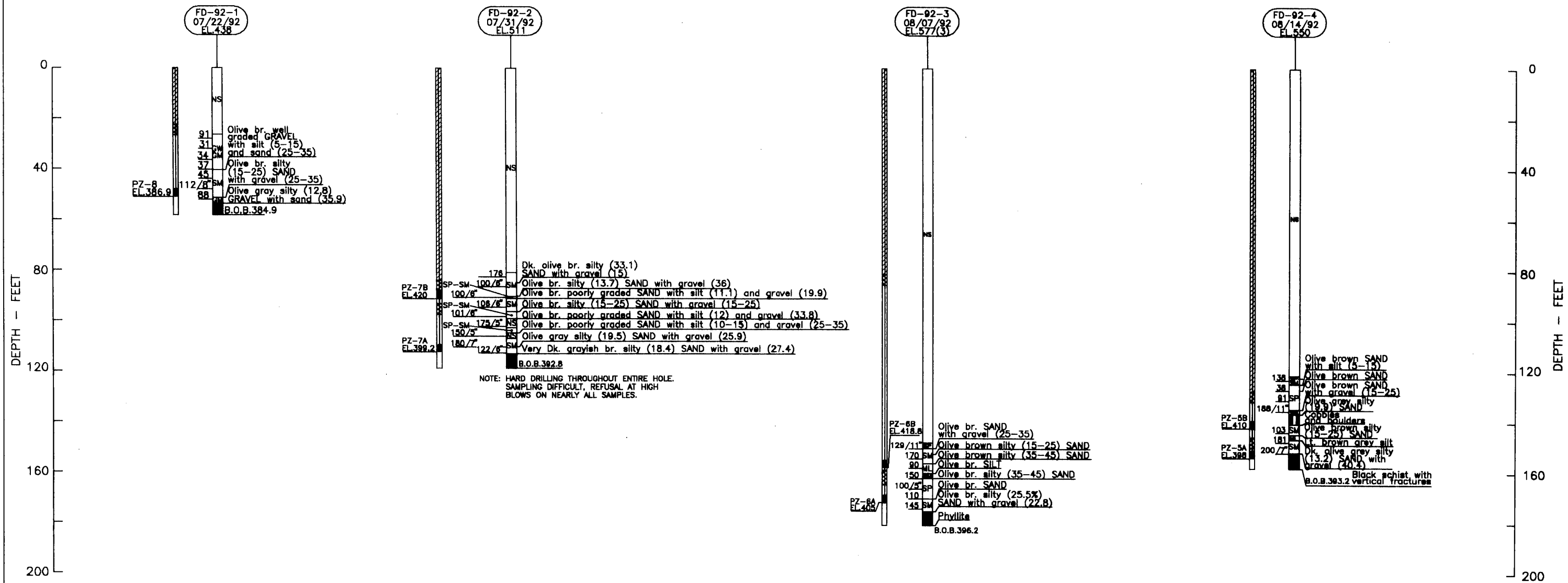
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION RIVER DAM
UNION VILLAGE, VERMONT

GENERAL LEGEND AND NOTES

SCALE: NONE

JULY 1995

FIGURE 6



NOTES:

1. TEST BORINGS AND PIEZOMETER LOGS PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
3. TOP EL.577 IS ASSUMED ON LOG FD-92-3.


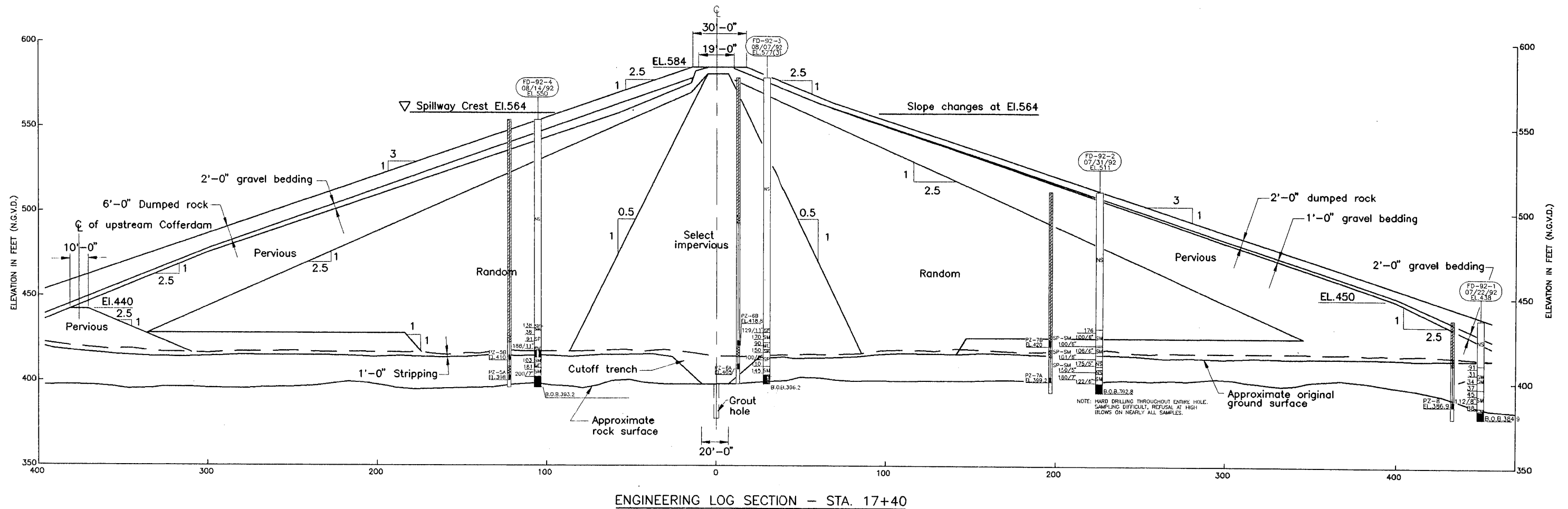
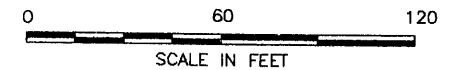
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CONNECTICUT RIVER BASIN FLOOD CONTROL OMPOMPANOOSUC RIVER UNION RIVER DAM UNION VILLAGE, VERMONT	
ENGINEERING LOGS PIEZOMETER EXPLORATIONS	
SCALE: AS SHOWN	JULY 1995

FIGURE 7



NOTES:

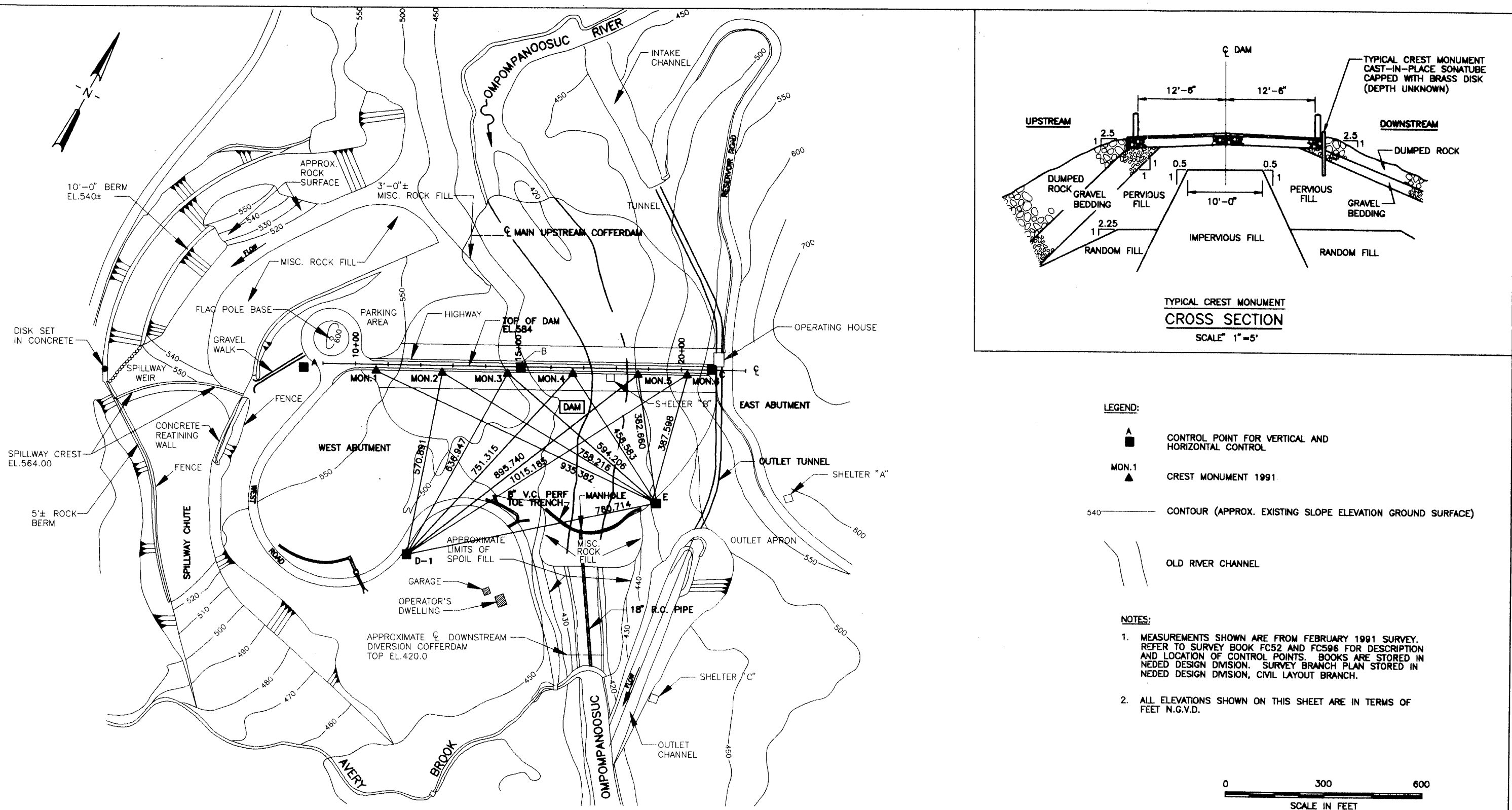
1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, UNIONVILLE DAM, CONNECTICUT RIVER BASIN, OMPOMPANOOSUC RIVER, VERMONT.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 6 FOR GENERAL LEGEND AND NOTES.
4. REFER TO FIGURE 7 FOR FULL DESCRIPTION OF ENGINEERING LOGS.
5. TOP EL.577 IS ASSUMED ON LOG FD-92-3.



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CONNECTICUT RIVER BASIN FLOOD CONTROL OMPOMPANOOSUC RIVER UNION RIVER DAM UNION VILLAGE, VERMONT	
ENGINEERING LOG SECTION STA.17+40	
SCALE: 1"=60'	JULY 1995

11163-004 B68

FIGURE 8



CONTROL POINT	NORTHING	EASTING	ELEVATION
A	NA	NA	589.777
E	471337.1800	564256.6700	NA
D-1	470854.1600	563843.5200	NA

DATE	1973	1975	1978	1985			1989			1994		
	ELEVATION	ELEVATION	ELEVATION	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION	NORTHING	EASTING	ELEVATION
MON 1	585.5865	585.5980	585.5810	472324.4933	563321.3740	585.5715	471324.5857	563321.3651	585.5675	471324.5499	563321.4318	585.5550
MON 2	584.9085	584.9105	584.9230	471407.1380	563501.7710	584.8680	471407.1647	563501.6938	584.8635	471407.1288	563501.7961	584.8440
MON 3	584.9815	584.9805	584.9700	471489.8300	563682.4910	584.9365	471489.8884	563682.4229	584.9250	471489.8630	563682.4896	584.9085
MON 4	584.8395	584.8440	584.8450	471572.5660	563863.1570	584.5915	471572.5916	563863.1259	584.5845	471572.5945	563863.1580	584.5645
MON 5	584.5550	584.5825	584.5450	471655.2930	564044.9780	584.5075	471655.2795	564043.9661	584.5085	471655.3279	564043.9752	584.4850
MON 6	584.6700	584.6780	584.6730	471716.8640	564178.4430	584.646	471716.8404	564178.4267	584.6410	471716.8681	564178.4580	584.6280

0 300 600
SCALE IN FEET

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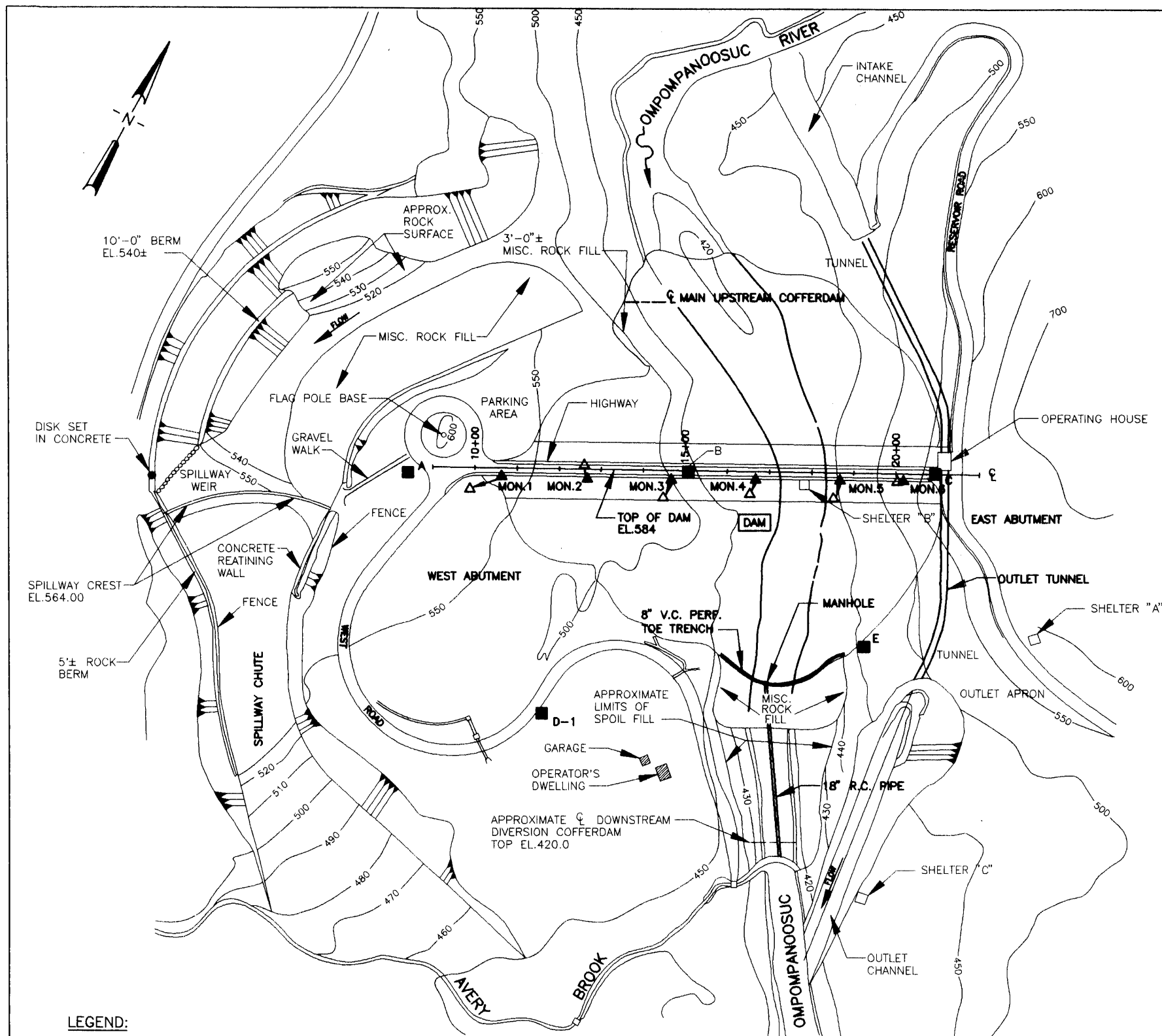
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

GENERAL LAYOUT, LOCATION
AND SURVEY

SCALE: 1" = 300'

JULY 1995

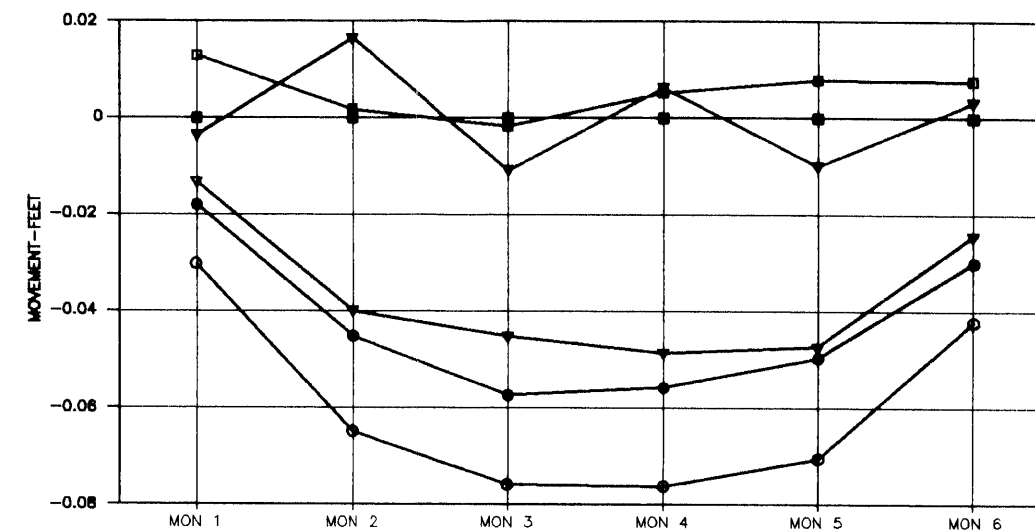


LEGEND:

- A ■ CONTROL POINT FOR VERTICAL AND HORIZONTAL CONTROL
- MON. 1 ▲ CREST MONUMENT 1985
- ▲ CREST MONUMENT 1994
- DIRECTION OF HORIZONTAL MOVEMENT
SCALE: 1 INCH = 0.3 FEET

NOTES:

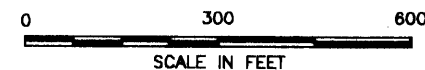
1. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET NGVD.



**ELEVATION
VERTICAL CREST MOVEMENT**

LEGEND:

- INITIAL ELEVATION 1973
- ELEVATION AS OF 1975
- ▲ ELEVATION AS OF 1978
- △ ELEVATION AS OF 1985
- ELEVATION AS OF 1989
- ELEVATION AS OF 1994



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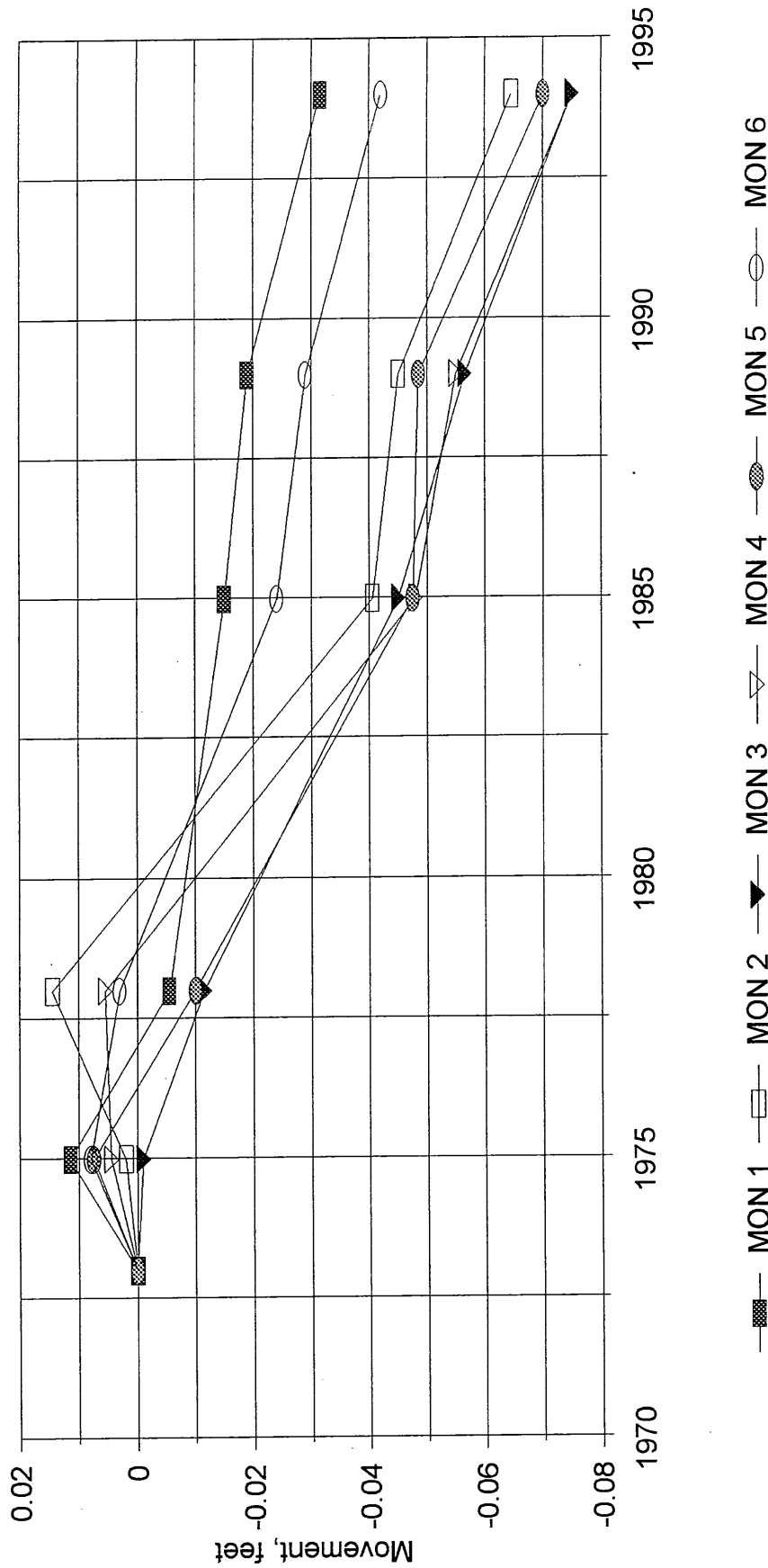
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

**HORIZONTAL AND VERTICAL
MOVEMENT**

SCALE: 1" = 300'

JULY 1995

FIGURE 10



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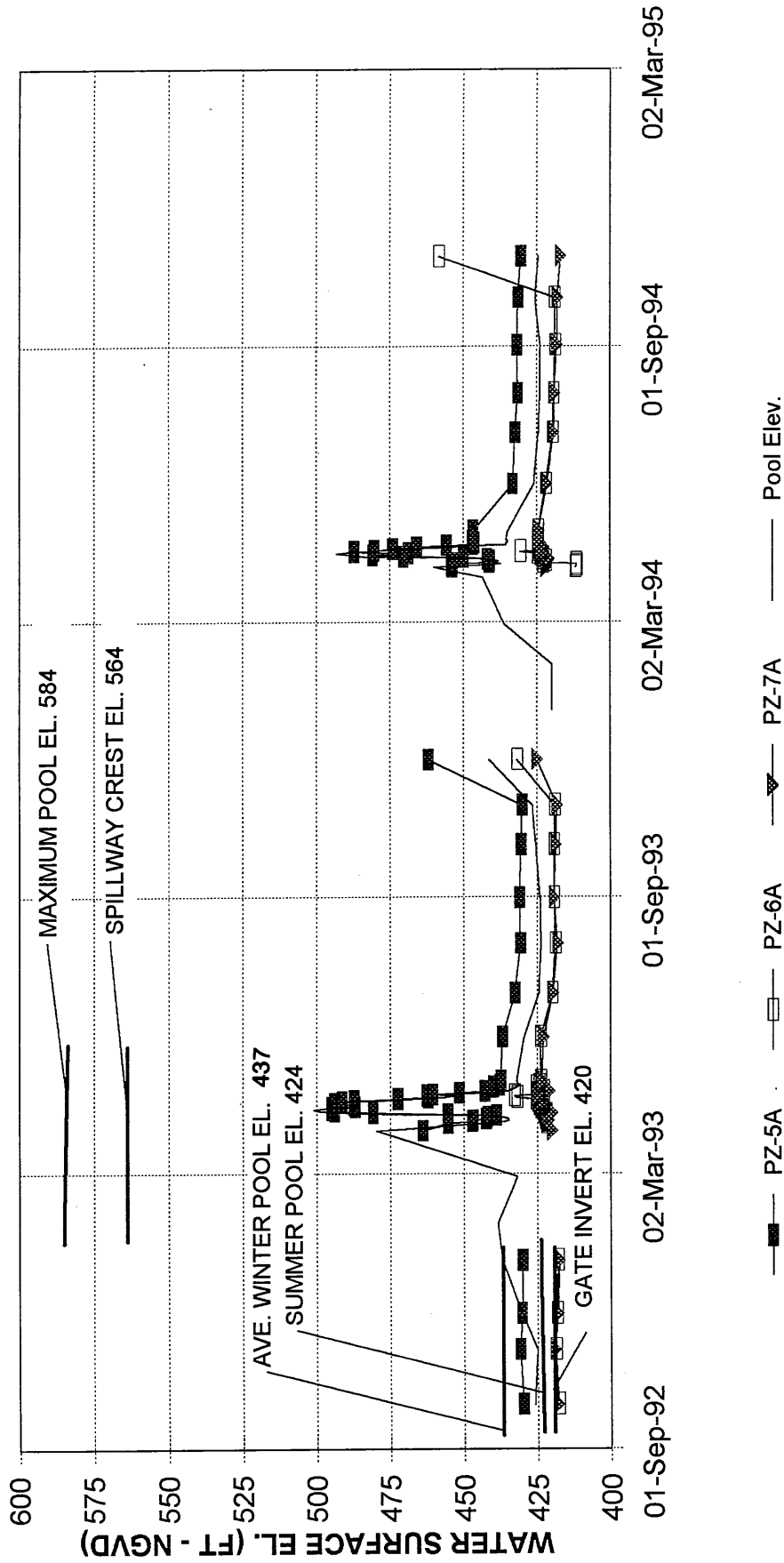
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOUNOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

SETTLEMENT vs. TIME CREST MONUMENTS

SCALE: AS SHOWN

JULY 1995



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-5A	398.0	552.0
PZ-6A	405.0	579.0
PZ-7A	399.2	513.0



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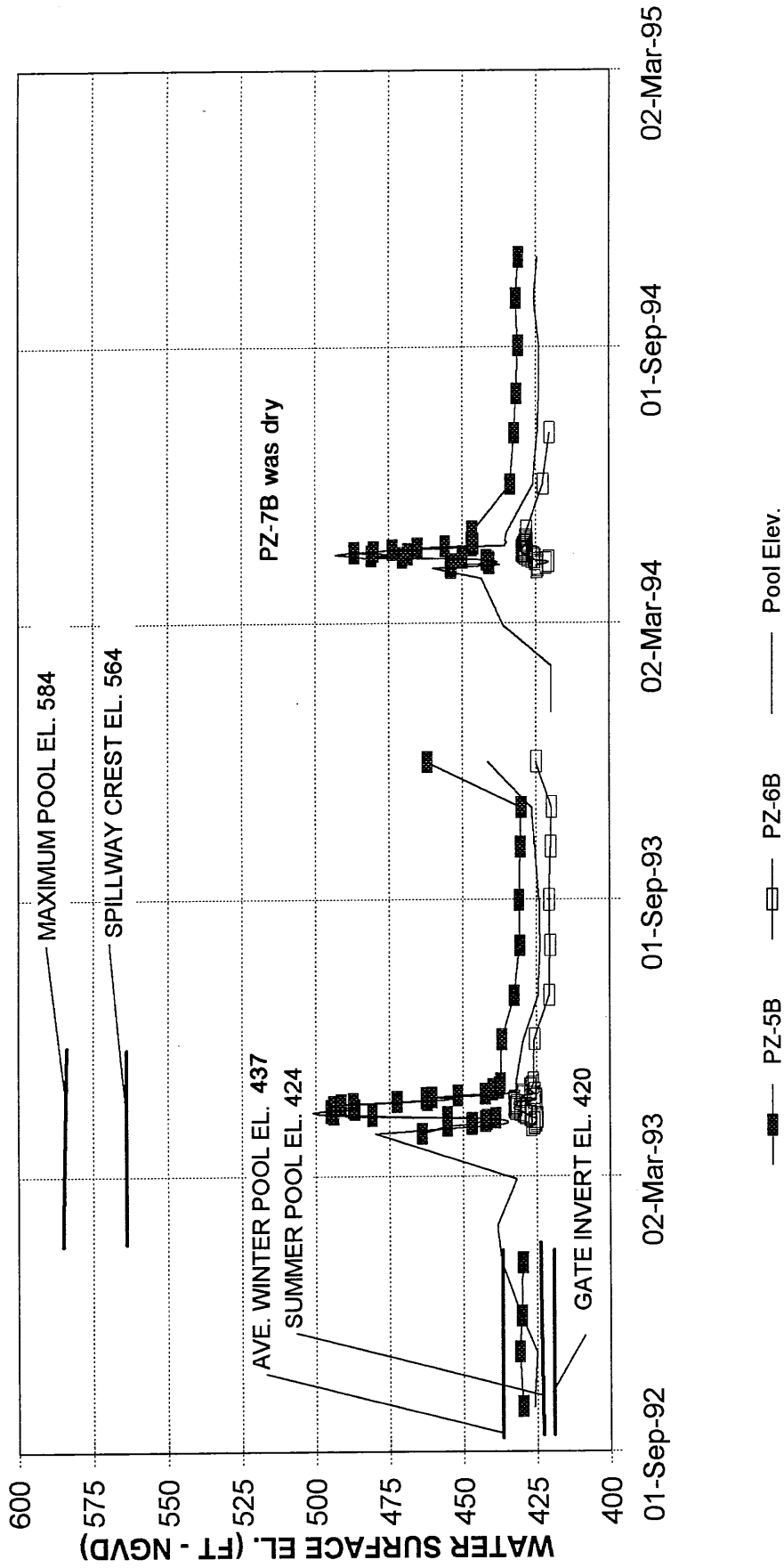
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPONANOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER DATA TIME HISTORY PLOTS
STATION 17+40
PZ-5A, 6A AND 7A

SCALE: AS SHOWN

JULY 1995



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-5B	410.0	552.0
PZ-6B	418.8	579.0



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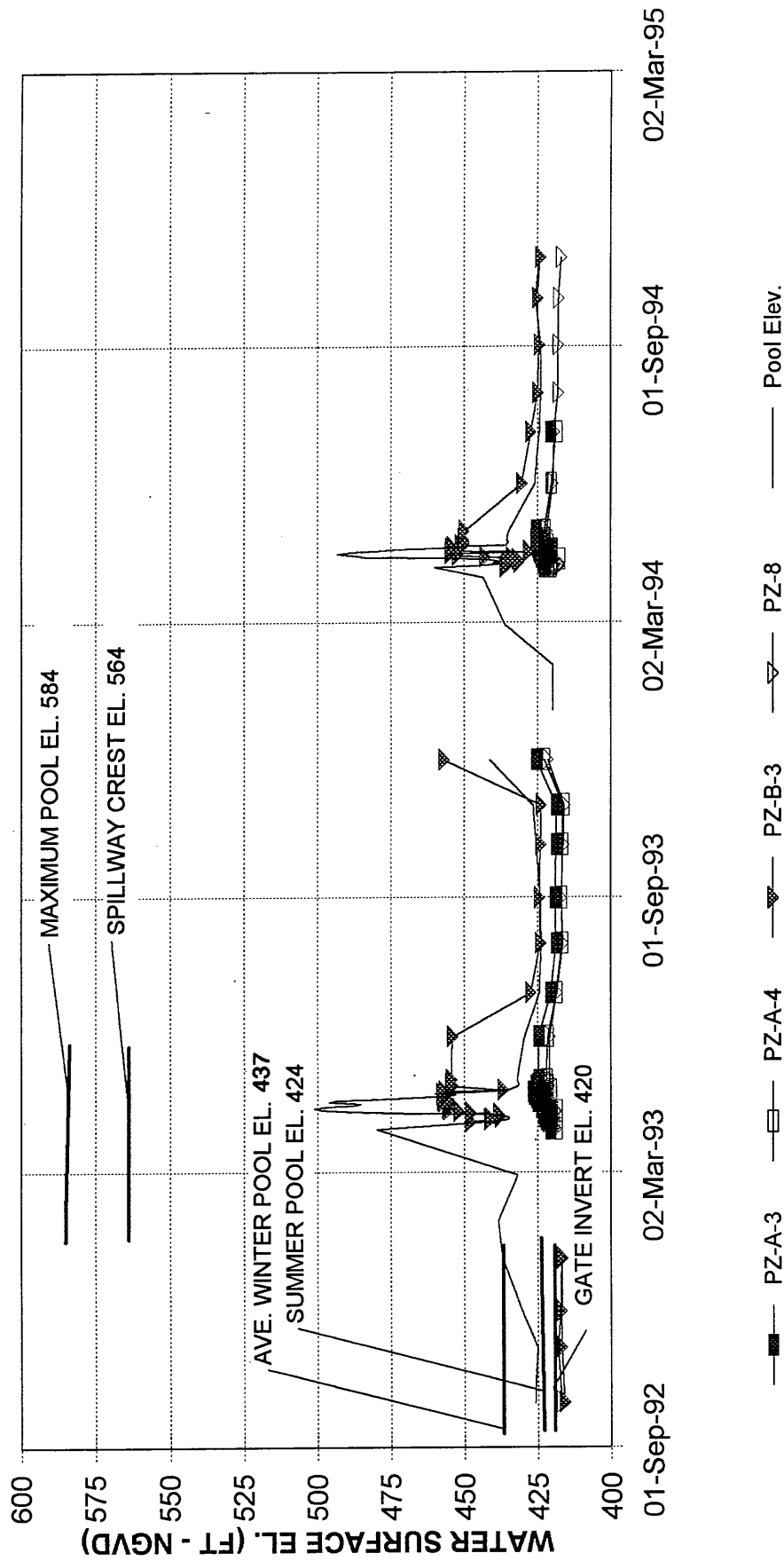
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER DATA TIME HISTORY PLOTS
STATION 17+40
PZ-5B AND 6B

SCALE: AS SHOWN

JULY 1995



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-8	386.9	440.0
PZ-A3	416.0	536.7
PZ-A4	417.7	486.7
PZ-B3	414.5	585.0

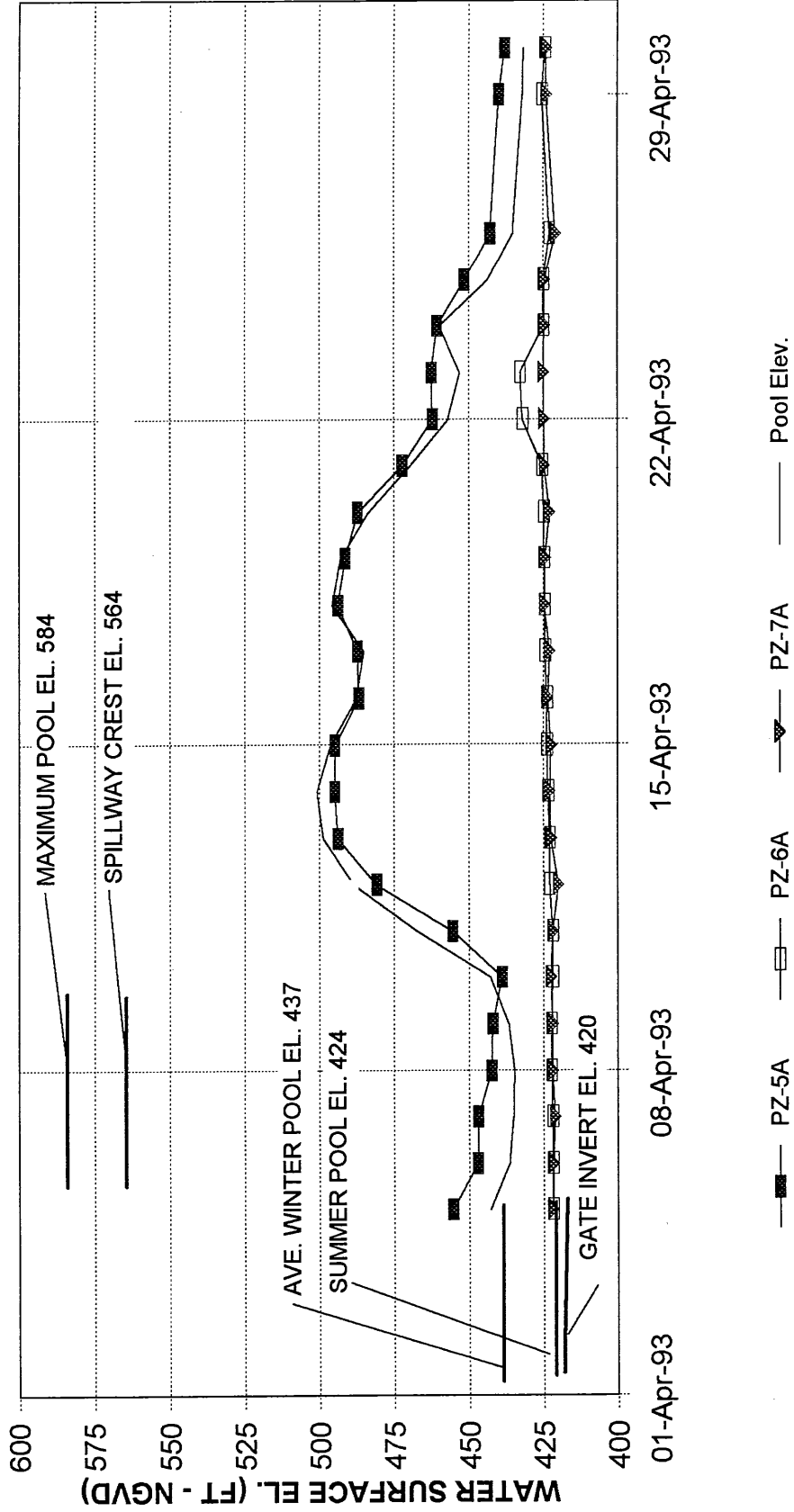
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER DATA TIME HISTORY PLOTS
STATION 17+40
PZ-8, A3, A4 AND B3

SCALE: AS SHOWN

JULY 1995



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-5A	398.0	552.0
PZ-6A	405.0	579.0
PZ-7A	399.2	513.0

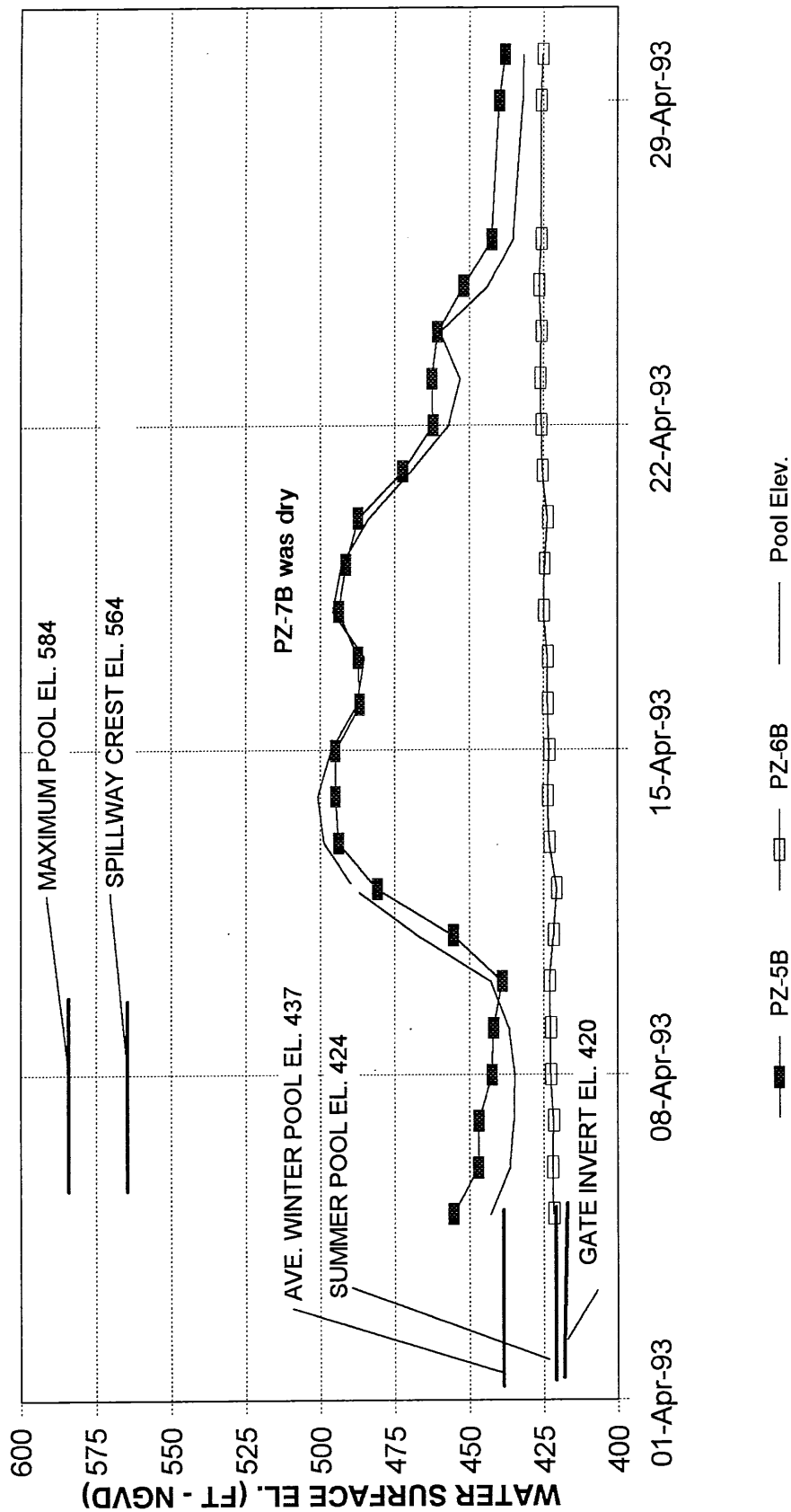
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

**APRIL 1993 EVENT
STATION 17+40
PZ-5A, 6A AND 7A**

SCALE: AS SHOWN

JULY 1995



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-5B	410.0	552.0
PZ-6B	418.8	579.0



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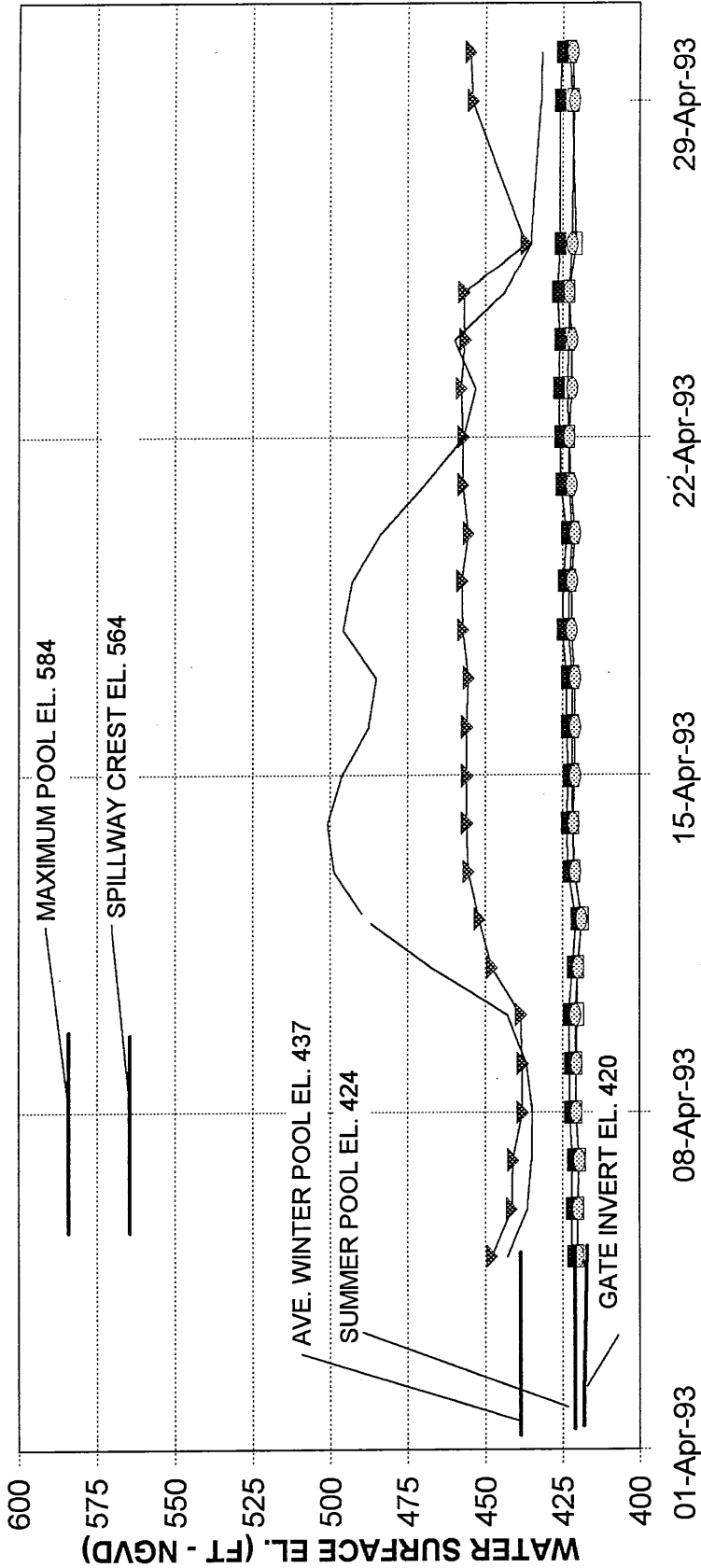
Geotechnical Engineers & Environmental Consultants

CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

APRIL 1993 EVENT
STATION 17+40
PZ-5B AND 6B

SCALE: AS SHOWN

JULY 1995



—■— PZ-A-3 —□— PZ-A-4 —▼— PZ-B-3 —○— PZ-8 — Pool Elev.

Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-8	386.9	440.0
PZ-A3	416.0	536.7
PZ-A4	417.7	486.7
PZ-B3	414.5	585.0



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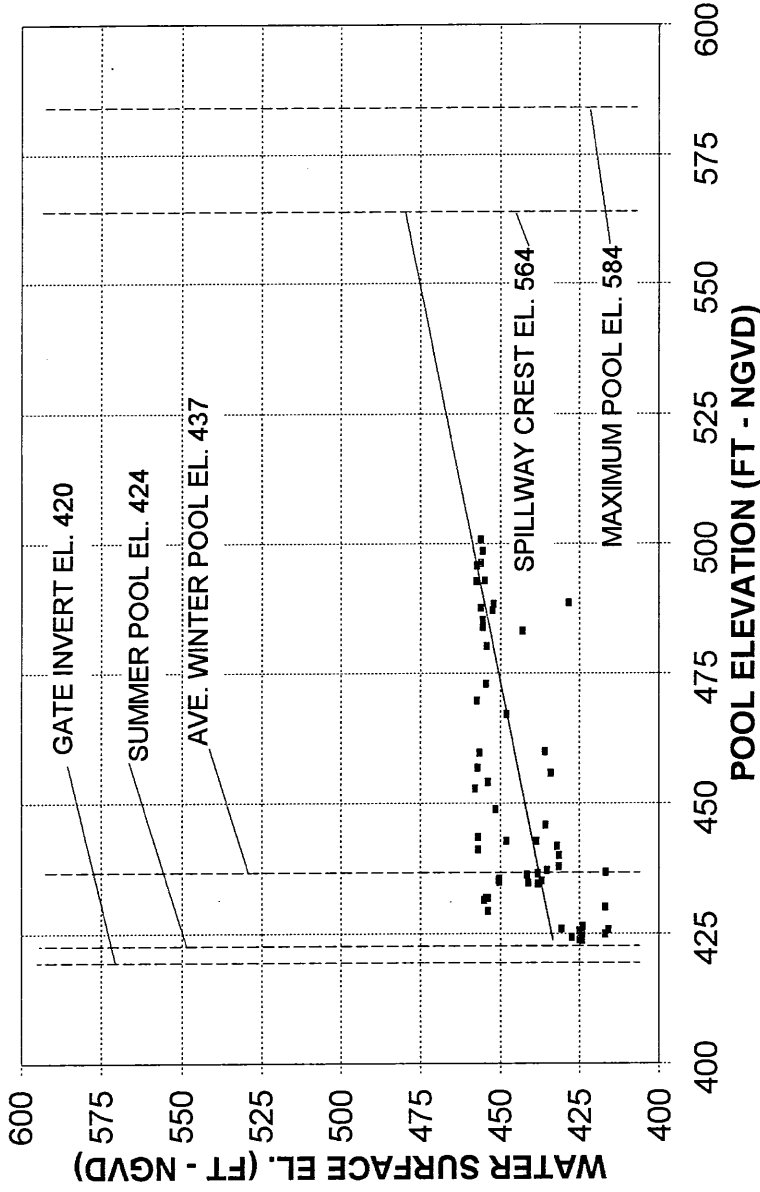
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPONANCOUS RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

APRIL 1993 EVENT
STATION 17+40
PZ-8, A3, A4 AND B3

SCALE: AS SHOWN

JULY 1995

PZ-B-3



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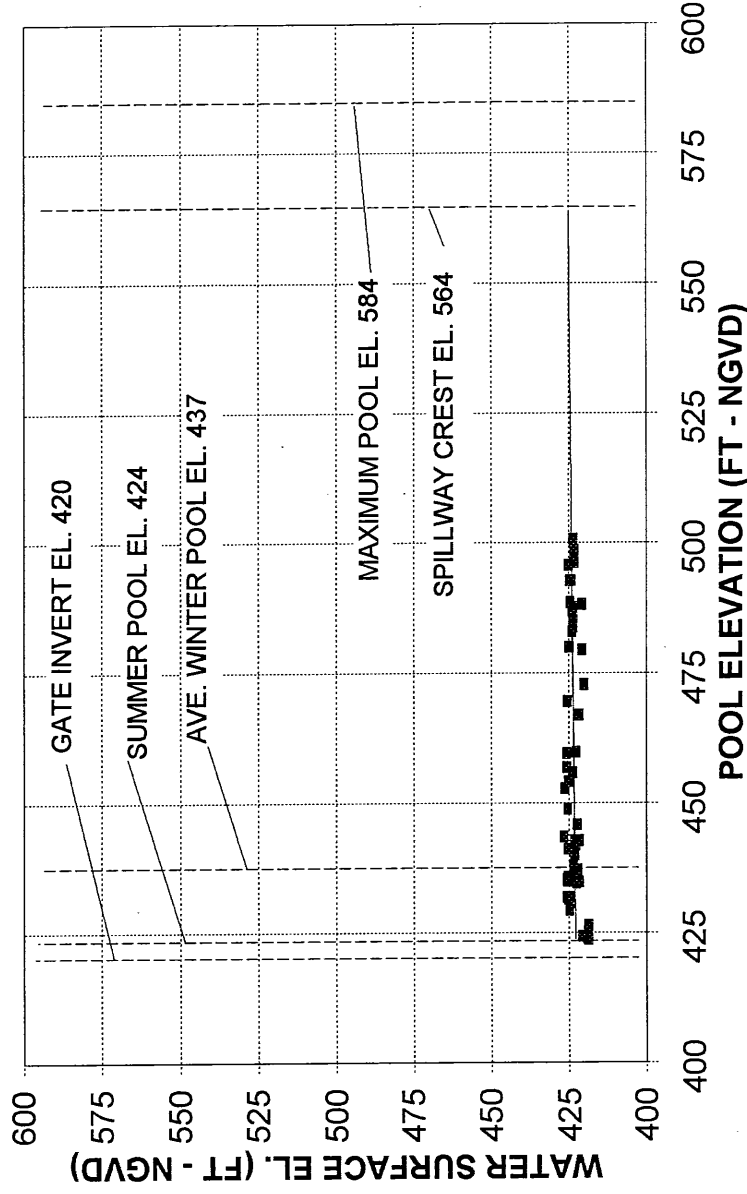
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

**PIEZOMETER ELEVATION
VS. POOL ELEVATION
PZ-B3**

SCALE: AS SHOWN

JULY 1995

PZ-A-3



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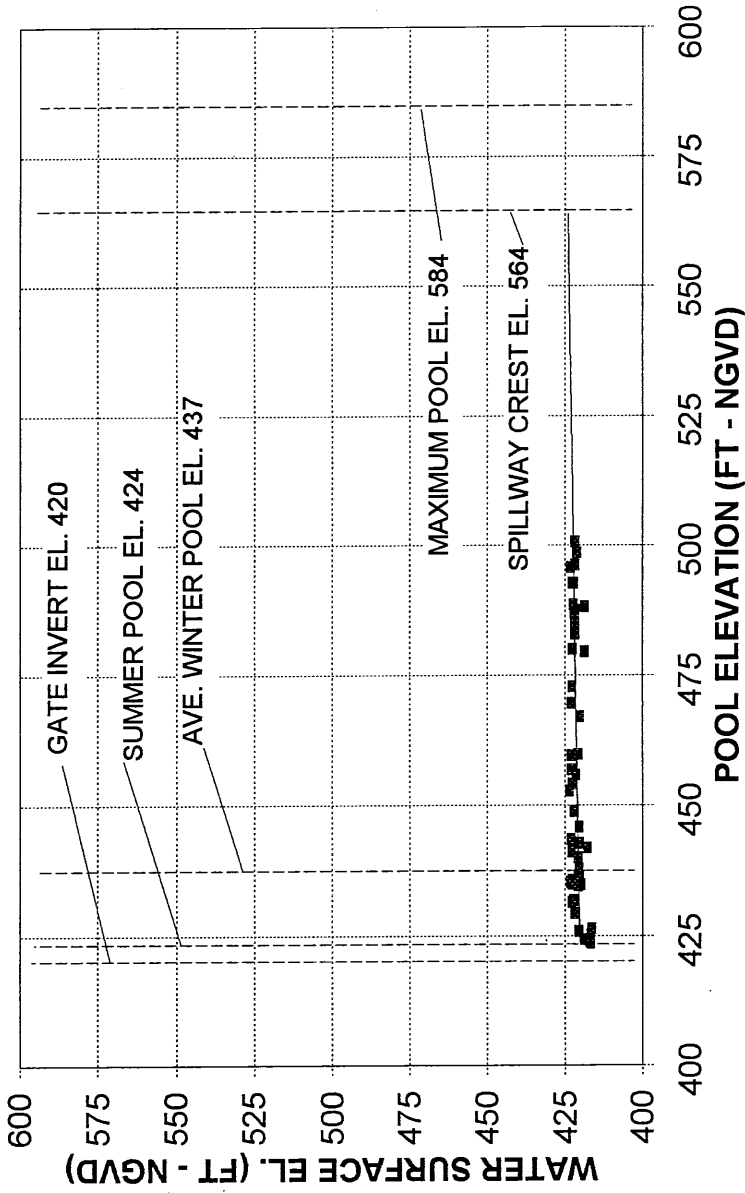
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPONANOCUSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER ELEVATION
VS. POOL ELEVATION
PZ-A3

SCALE: AS SHOWN

JULY 1995

PZ-A-4



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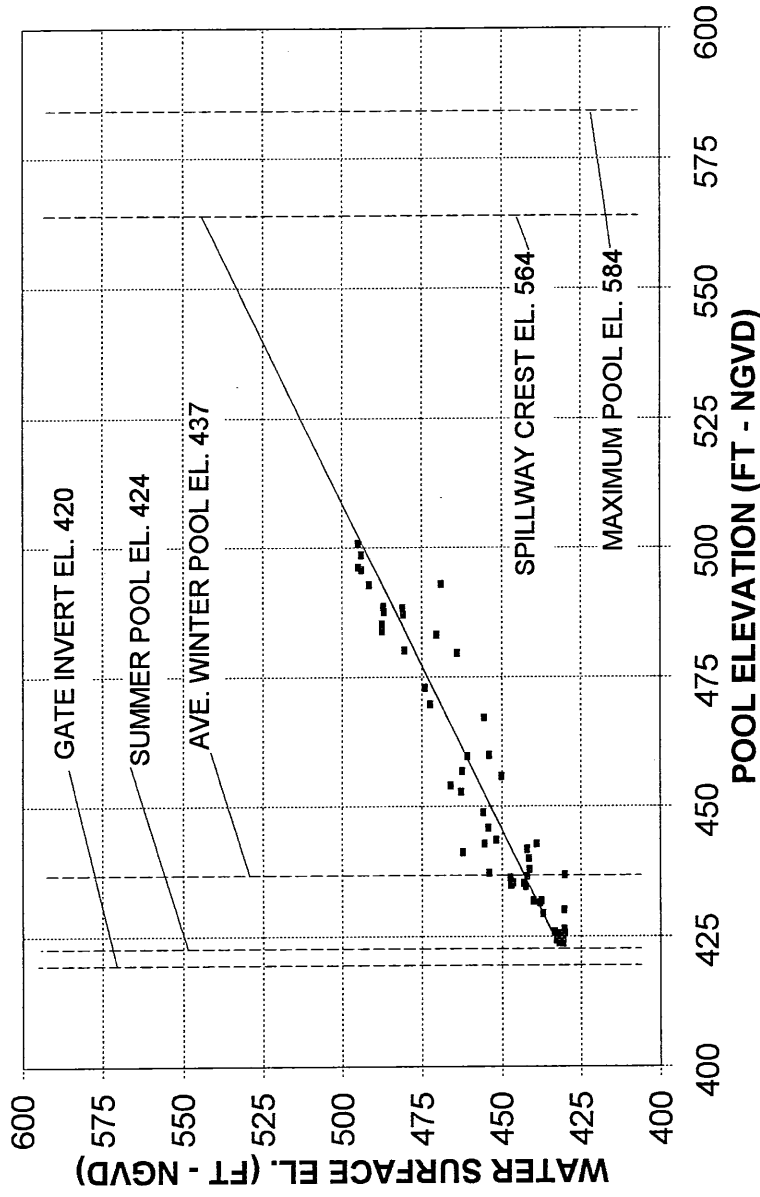
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPOUSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

**PIEZOMETER ELEVATION
vs. POOL ELEVATION
PZ-A4**

SCALE: AS SHOWN

JULY 1995

PZ-5A



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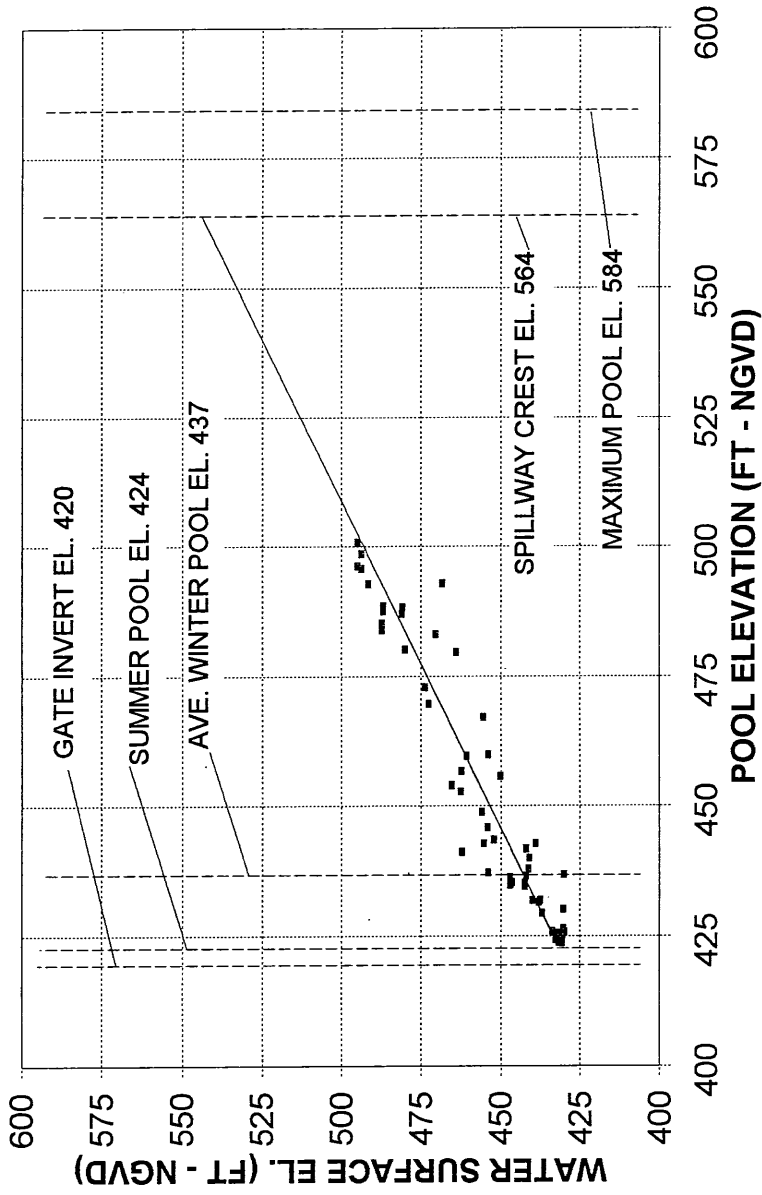
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER ELEVATION
vs. POOL ELEVATION
PZ-5A

SCALE: AS SHOWN

JULY 1995

PZ-5B



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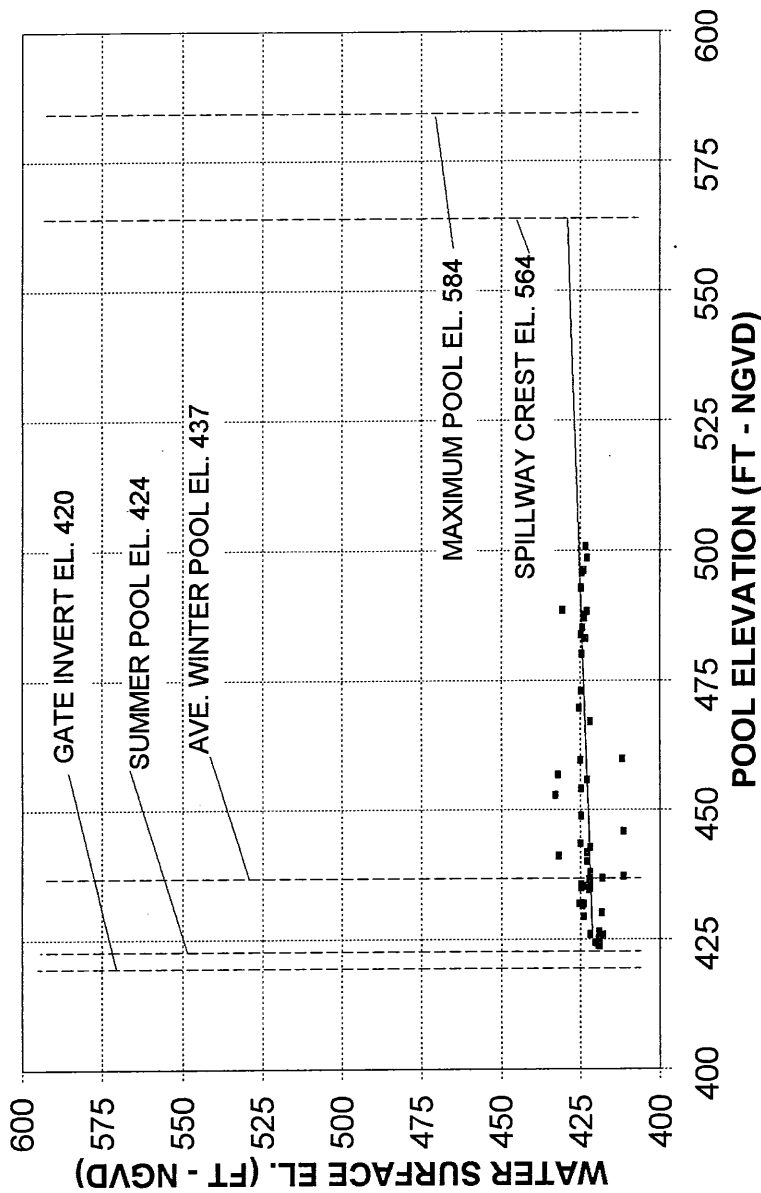
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

**PIEZOMETER ELEVATION
vs. POOL ELEVATION
PZ-5B**

SCALE: AS SHOWN

JULY 1995

PZ-6A



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Geotechnical Engineers & Environmental Consultants

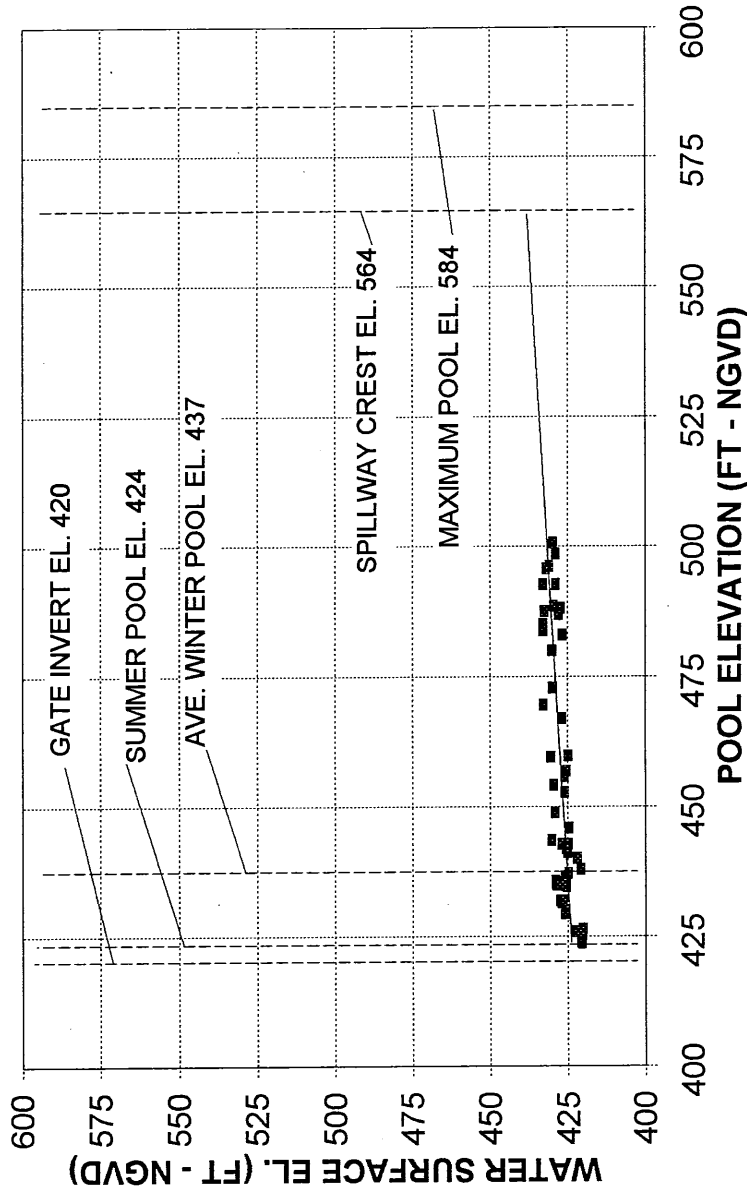
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPANNOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER ELEVATION
vs. POOL ELEVATION
PZ-6A

SCALE: AS SHOWN

JULY 1995

PZ-6B



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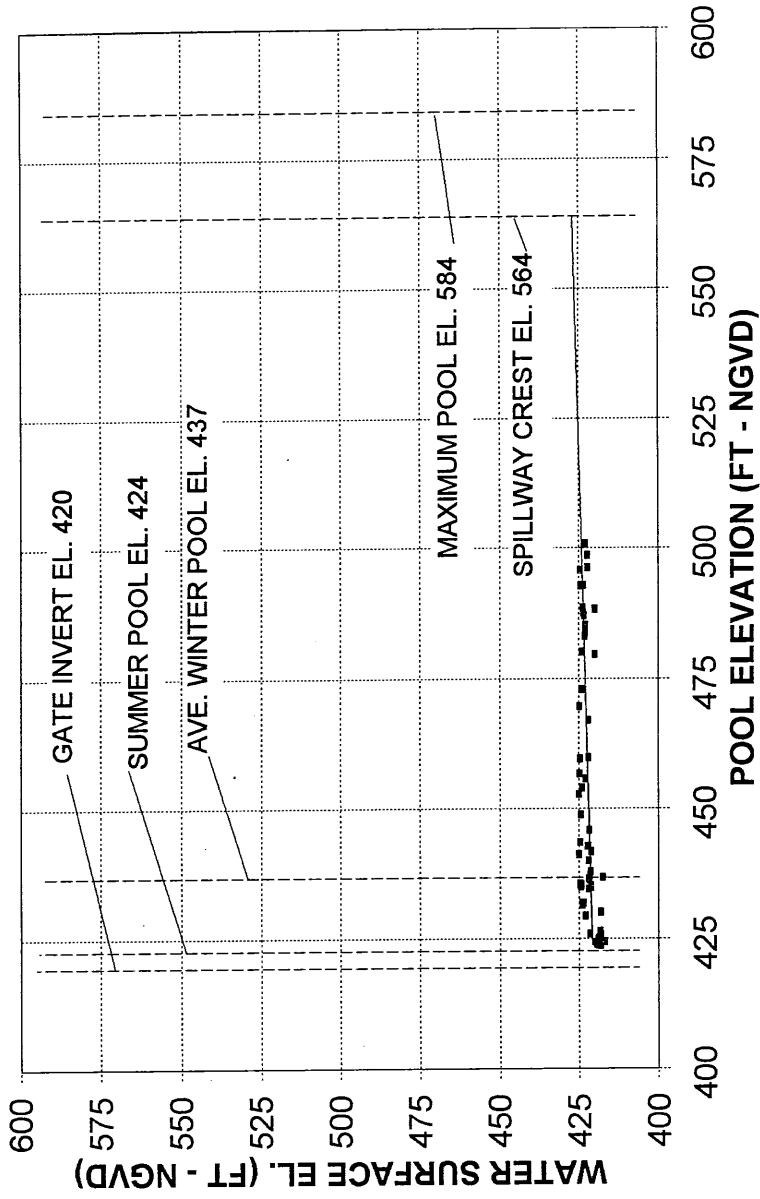
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPOOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

PIEZOMETER ELEVATION
VS. POOL ELEVATION
PZ-6B

SCALE: AS SHOWN

JULY 1995

PZ-7A



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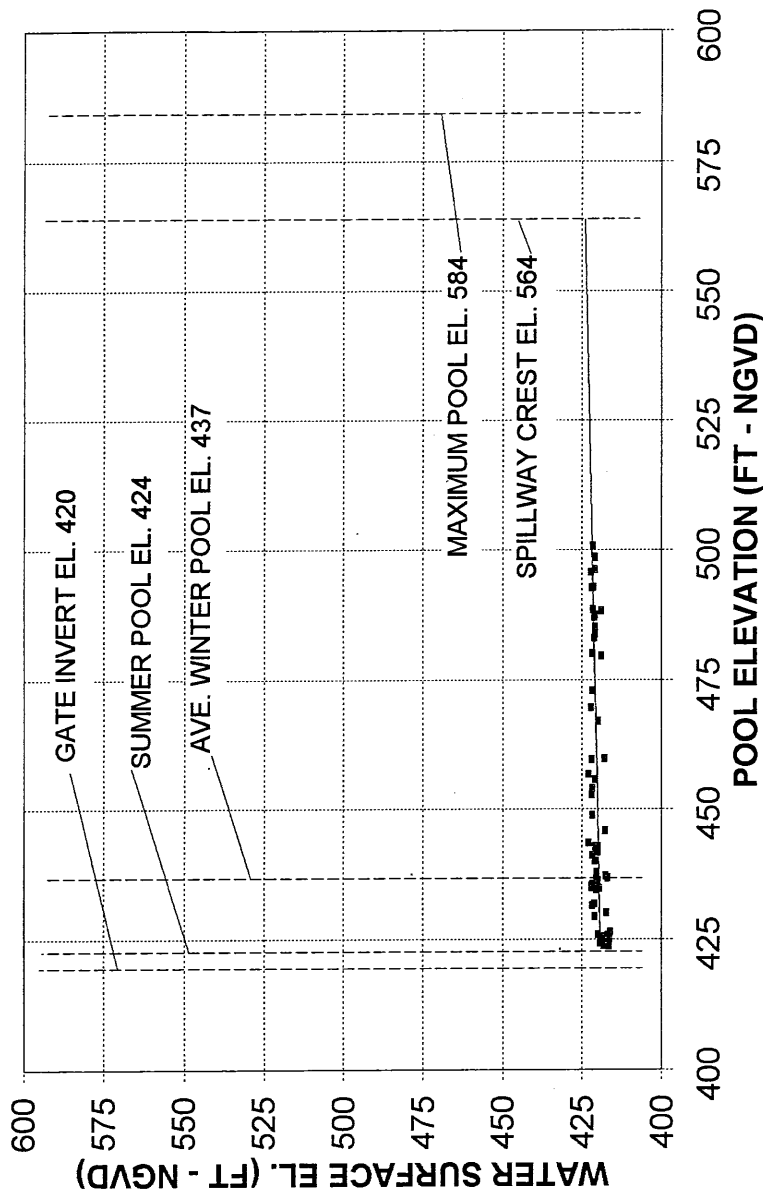
CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION VILLAGE DAM
UNION VILLAGE, VERMONT

**PIEZOMETER ELEVATION
vs. POOL ELEVATION
PZ-7A**

SCALE: AS SHOWN

JULY 1995

PZ-8

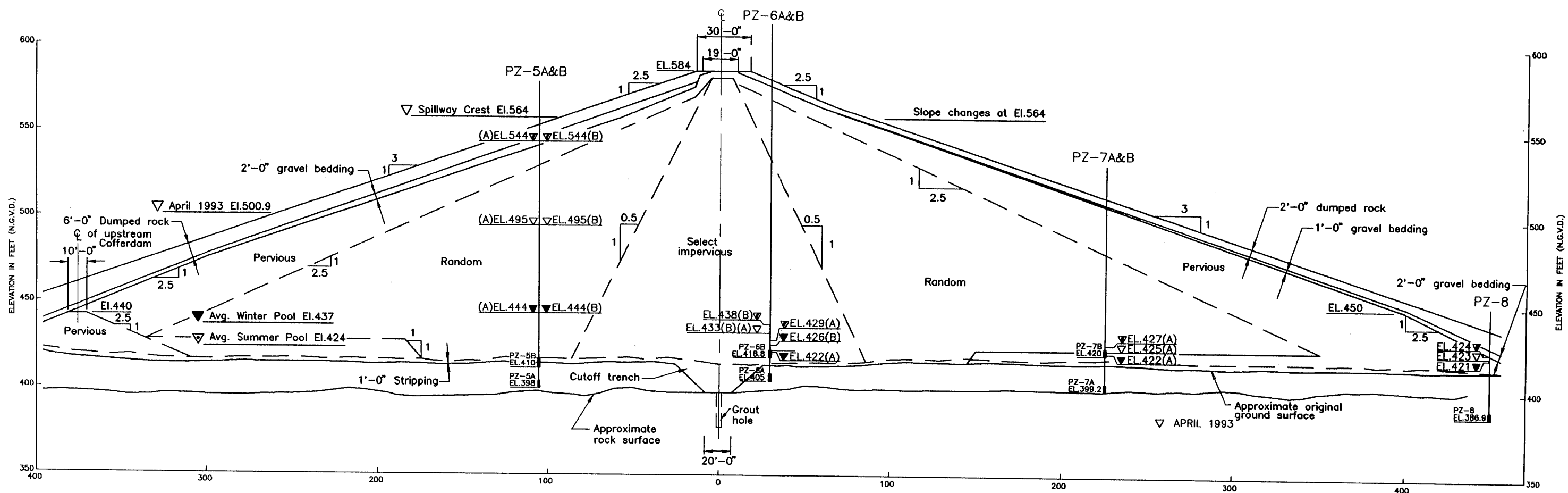


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Geotechnical Engineers & Environmental Consultants
 CONNECTICUT RIVER BASIN FLOOD CONTROL
 OMPOMPOOSUC RIVER
 UNION VILLAGE DAM
 UNION VILLAGE, VERMONT

**PIEZOMETER ELEVATION
vs. POOL ELEVATION
PZ-8**

SCALE: AS SHOWN
 JULY 1995



ENGINEERING LOG SECTION - STA. 17+40

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, UNIONVILLE DAM, CONNECTICUT RIVER BASIN, OMPOMPANOOSUC RIVER, VERMONT."
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 6 FOR GENERAL LEGEND AND NOTES.
4. PZ-7B READ DRY FROM OCTOBER 1, 1992 THROUGH OCTOBER 31, 1994.

LEGEND:

- ▼ PIEZOMETER LEVEL AT AVERAGE WINTER POOL
- ▽ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1993
- ▽ PIEZOMETER LEVEL AT AVERAGE SUMMER POOL

0 60 120
SCALE IN FEET



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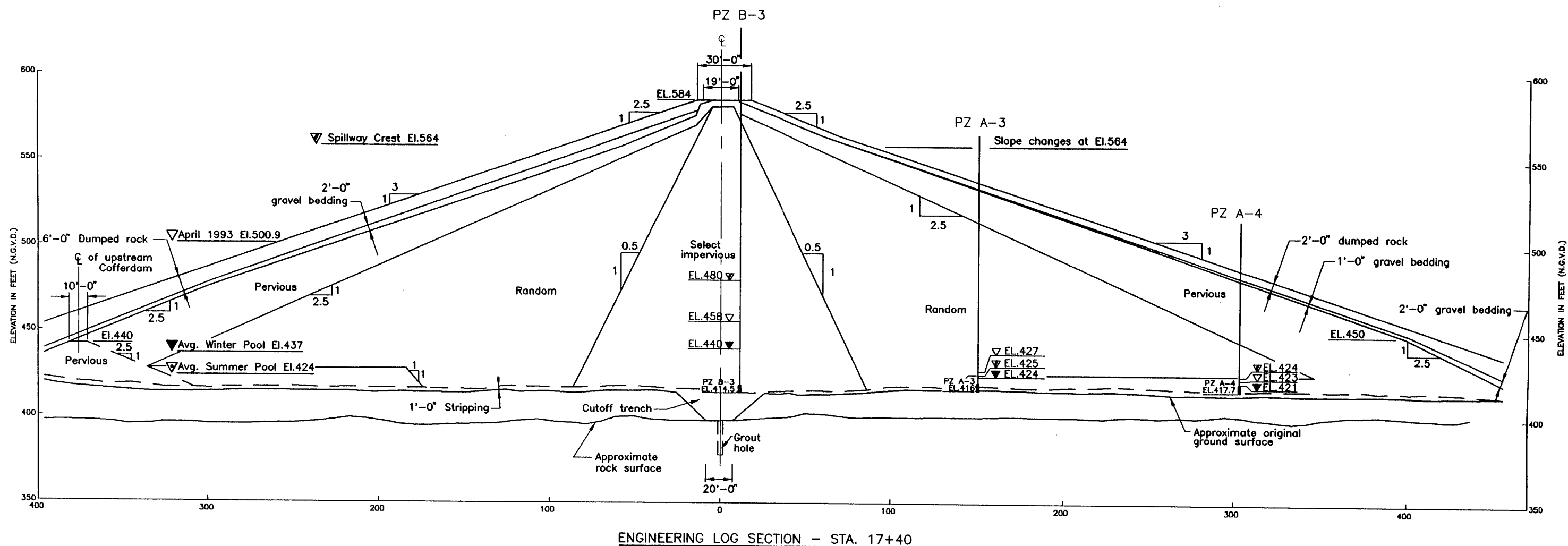
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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION RIVER DAM
UNION VILLAGE, VERMONT

PIEZOMETER LEVEL, AVERAGE WINTER POOL
AND PROJECTED TO SPILLWAY FOR
STA.17+40 - PZ-5A&B, 6A&B AND 7A&B

SCALE: 1"=60'

JULY 1995



ENGINEERING LOG SECTION - STA. 17+40

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, UNION VILLAGE DAM, CONNECTICUT RIVER BASIN, OMPOMPANOOSUC RIVER, VERMONT.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 6 FOR GENERAL LEGEND AND NOTES.
4. PZ A-3, A-4 AND B-3 TIP ELEVATIONS CORRESPOND TO SOUNDING ELEVATION PERFORMED IN 1988.

LEGEND:

- ▼ PIEZOMETER LEVEL AT AVERAGE WINTER POOL
- ▽ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1993
- ▽ PIEZOMETER LEVEL AT AVERAGE SUMMER POOL

0 60 120
SCALE IN FEET

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CONNECTICUT RIVER BASIN FLOOD CONTROL
OMPOMPANOOSUC RIVER
UNION RIVER DAM
UNION VILLAGE, VERMONT

PIEZOMETER LEVEL, AVERAGE WINTER POOL
AND PROJECTED TO SPILLWAY FOR
STA.17+40 - PZ A-3, A-4 AND B-3

SCALE: 1"=60' JULY 1995

APPENDIX A
Standards for Settlement Survey

APPENDIX A

STANDARDS FOR SETTLEMENT SURVEYS

1. Control points are stamped brass disks preferably set in a ledge area. Where no ledge is available, they are set in concrete bounds placed flush with the ground.
2. Control points are set in areas such that the maximum possible number of crest monuments on the dam are visible.
3. Control points are tied into four reference points by distance. This provides a check each time they are occupied for settlement surveys or allow them to be replaced if found to be destroyed.
4. Distances are read and recorded between settlement bounds. Both distance and angle are read and recorded from the control points that are being occupied to locate each settlement bound on the dam.
5. In locating each settlement bound, a control point will be occupied setting 0-00'-00" (referenced line of site) on a second control point, reading and recording both interior and exterior angle closure, along with distances through each settlement bound located on the dam. Each settlement bound is located from a minimum of two control points. These locations are third order, class II survey with relative accuracies of not less than 1 part in 5,000.
6. Levels are run from control points through each settlement bound on the dam with a return run back into the control points to check the elevation closure on the run. Closure tolerance should be no greater than 0.05 feet. These levels are third order, class I survey with relative accuracies no less than 1 part in 10,000.
7. Crest monument surveys are performed using Topcon EDM Total Stations and recording both horizontal angles and horizontal distances.

PROCEDURE FOLLOWED FOR SETTLEMENT SURVEYS

The horizontal and vertical monitoring plan for settlement bound movement points employed a combination of triangulation and trilateration angle and distance techniques to survey the control network. Control points, in the form of stamped brass disks, were placed off the dam structure in areas from which the entire length of the dam is visible. Settlement bounds themselves, with stamped brass disks, were placed on the control points. Horizontal coordinates of the control points are based on the State Plane Coordinate System. Elevations of the control points are based on the National Geodetic Vertical Datum (NGVD). Control points are occupied utilizing an EDM Total Station; observed distances and angles (interior and exterior angles), between control points and settlement bound establishing permanent bench marks. Standard leveling techniques are followed. Levels are double run and the means of the front and back runs were computed and recorded.

DATA ADJUSTMENT

A combination of triangulation and trilateration surveying techniques are applied. Each crest monument is located from two control points whereby two sets of coordinates are calculated using

adjusted field angles and compliments and EDM distances. The two sets of coordinates are averaged to give a net result. The averaged coordinates are then established on each settlement bound for use in determining shifts in the dam surface structure over a period of years by comparing repetitive surveys.